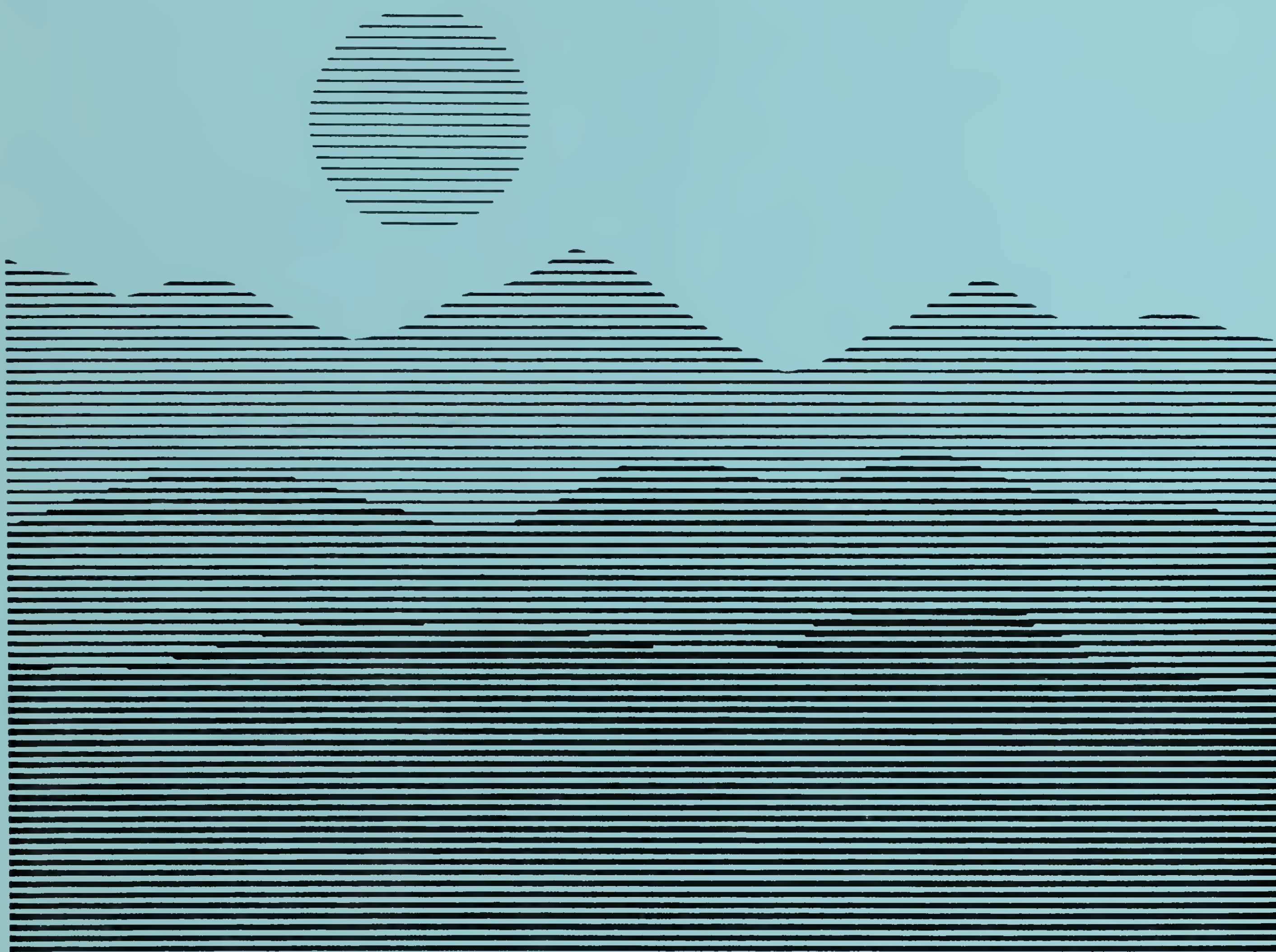
Reclamation Research Plans For Alaska National Park System Units



ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

RECLAMATION RESEARCH PLANS FOR ALASKA NATIONAL PARK SYSTEMS UNITS

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Submitted to:

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1.0 INTRODUCTION

1.1 BACKGROUND

In 1980, the Alaska National Interest Lands Conservation Act (ANILCA) expanded and established national park system units throughout Alaska. This act allows the continued exercise of valid existing rights of individuals on patented and unpatented mining claims within these expanded parks and preserves. At the same time, the National Park Service (NPS) must see to it that areas within these parks and preserves which are no longer actively mined are restored to approximate preexisting environmental conditions.

Operations associated with mining and mining claims within National Park Service (NPS) units are governed by NPS regulations (36 CFR 9A) which require an approved plan of operations. The key element of this plan is the development of a suitable mine reclamation plan. NPS standards for acceptable reclamation include:

- Removal of all equipment and debris;
- Prevention of surface subsidence;
- Replacement of overburden and spoil (where practicable);
- Recontouring;
- Replacement of topsoil; and
- The reestablishment of native vegetative communities.

Two major types of mining are and have been used throughout Alaska including NPS units: 1) lode mining in which the ore is extracted from consolidated rock and 2) placer mining in which heavy metals are obtained from unconsolidated materials such as alluvium or talus deposits. The types of disturbance and reclamation problems are substantially different for both types of mining. Related facilities such as access roads create similar problems for all mining operations.

Lode mining in Alaska frequently occurs on moderate to steep slopes and results in the development of open tunnels, mine tailings deposited on the surface downslope from the mining operations, and the deposition of toxic materials (e.g., heavy metals) at the surface. Reclamation

problems include slope stabilization, recontouring, revegetation of toxic and/or nutrient-poor materials, and closure of adits and tunnels. Hazardous materials (e.g., dynamite, chemical solvents) are also associated with active and recently abandoned mining operations.

In Alaska, placer mining occurs in a variety of situations ranging from extensive alluvial deposits along major rivers to small pockets of unconsolidated materials along swift-flowing streams located in high mountain valleys. Recontouring, restoration of the stream (including the channel configuration, water quality, and habitat characteristics), erosion prevention, and revegetation are major considerations. Removal of equipment and debris will also be important, particularly for large operations.

Climatic and other environmental conditions in Alaska impose a unique set of restrictions on reclamation. Short growing season, low summer precipitation (in some areas), cool to cold temperatures, dessicating winds, permafrost, low soil temperatures, and low nutrient availability are all factors which must be considered in devising successful schemes for the reclamation of mines and associated facilities.

The remoteness of many mine sites may create indirect reclamation problems. Wet surface conditions typically found in low flat areas can prevent overland travel between the spring thaw and winter freezeup. Implementation of reclamation procedures may also cause considerable additional disturbance if the type of equipment to be used and the timing and method of equipment transport are not carefully considered as part of the planning process.

Many abandoned mine sites and active mining claims exist within NPS units distributed throughout Alaska. There is a need to reclaim these abandoned sites and at the same time develop reasonable guidelines to reclaim active mine sites within national parks and preserves. These guidelines should address reclamation techniques, schedule, monitoring, and bonding levels. This study was undertaken to address these issues. Study objectives are:

- To develop experimental reclamation and monitoring plans for abandoned lode mines, placer mines, and access roads in Alaska NPS units;
- To provide a ranking of environmental zones with respect to reclamation potential and associated costs for pertinent Alaska NPS units; and
- To suggest recommendations on future research needs with respect to reclamation in Alaskan environments.

The emphasis of this report is on the development of experimental reclamation and monitoring plans for disturbed areas in Denali and Wrangell-Saint Elias National Parks and Preserves. The reclamation approaches developed as a result of this effort will also apply to abandoned mines in other Alaska National parks and to operational mines within many national park system units.

1.2 RECLAMATION TECHNOLOGY

The Alaskan environment provides harsh natural conditions which restrict plant growth and which require specific techniques and materials to achieve successful reclamation. While techniques developed in regions outside the artic and subartic areas are generally applicable, important differences exist. Extensive reclamation knowledge was gained during construction of the oil pipeline during the 1970's. The philosophy for those efforts was to establish vegetative cover for erosion control purposes. To achieve this objective, the companies used primarily agronomic species and relied on extensive management techniques such as watering, special fertilizer type, mulches, and maintenance. Experience has shown that when native plant communities are involved, these reclamation approaches will not achieve the desired results.

Reclamation in Alaska requires consideration of standard component (e.g., removal of debris, recontouring, topsoiling, streambed restructuring) in the context of arctic and subalpine environments. The major consideration, however, is successful revegetation under extreme environmental conditions.

While it is not the purpose of this study to provide a detailed literature review of revegetation techniques in arctic and subalpine environments, a brief review of revegetation technology is presented here. This background provides the rationale for the treatments to be evaluated in the experimental studies. Pertinent literature reviews and evaluations regarding revegetation techniques in arctic and alpine environments are available in Kubanis (1982), Peterson & Peterson (1977), and Johnson & Van Clive (1976).

Additional guidance on reclamation of mined lands in Alaska is provided by a series of recent documents published by the U. S. Forest Service (Reeves and Roelofs, 1982; U. S. Forest Service, 1982) and by the Alaska Department of Fish and Game (Entrix, 1986a and 1986b). Although the recommendations for mine site reclamation provided in these documents are sound, many of the proposed techniques either require maintenance or are unacceptable for implementation in national parks because of their use of unnatural structures to achieve reclamation objectives.

Reclamation techniques regarding seedbed preparation, seeding methods, rates, and season in Alaska are well documented (Alaska Rural Development Council, 1983) and these techniques have not been included as test parameters for the proposed reclamation studies. Mulching and water harvest techniques were not selected for the experimental tests.

The parameters to be tested in the proposed reclamation study include:

- <u>Topsoil Material</u>--Soil Material containing a higher percentage of silt and clay size particles (fines) has been found to correlate with the re-establishment of vegetation in areas disturbed by placer mining in Alaska (Holmes, 1982). Materials containing fines, when used for topsoil, are likely to provide a more suitable plant growth medium since they will enhance water retention and are more likely to provide nutrients.
- <u>Fertilizer</u>--Nutrient deficiencies (nitrogen, phosphorus, and potassium) are common in Alaska soils, particularly in disturbed areas. These deficiencies result primarily from the cold soil temperatures which limit the decomposition rate

through decreasing bacterial activity (Bliss, 1973). Fertilizer can improve vegetative establishment and survival (Densmore, 1977) and increase production.

The correlation between additional nitrogen and phosphorus (fertilizer) and increased growth and production is well documented (Haag 1972; Hernandez 1973; Mitchell, et.al. 1978). Fertilizer has not been selected as a parameter to investigate increased production, but rather to determine the potential of natural revegetation in areas where a good seedbed preparation has been done and fertilizer applied.

- Natural Revegetation--Natural revegetation has been recommended as an alternative for disturbed sites where erosion potential is limited (Kubanis, 1982). Natural reinvasion of native species can be enhanced through proper seedbed preparation and fertilizer application.
- Plant Material--Native plant materials are preferable to the use of agronomic species. Agronomic species have been shown to die out unless maintained by fertilizer treatment and watering (Mitchell, 1972). Agronomic species also inhibit the invasion and establishment of preferred native plant species. Therefore, the plant species recommended for testing are limited to native species and primarily shrub species. A limitation on use of native species is the lack of commercially available seed and plant materials. Some species are currently being tested at the Plant Materials Center at Palmer, Alaska (Moore, 1986). These species are included as special plant species trials in this study area if seeds are available.

2.0 EXPERIMENTAL RECLAMATION PLANS

Three study sites were selected by the NPS for development of experimental reclamation and monitoring plans. These sites represent a broad range of reclamation concerns pertinent to placer and lode mine operations and access roads in Alaska's National Parks. A brief site description, discussion of the particular reclamation concerns, and presentation of the experimental reclamation plan are provided for each of the three designated sites.

The development of these plans is based on certain assumptions. The lower Glen Creek site is currently affected by upstream mining operations. The implementation of a reclamation plan for this area will be of limited value if the effects of upstream mining including sedimentation, water quality control, and access across affected areas are not controlled or eliminated. The Nelson Prospect/Radovan Gulch sites contain hazardous materials which are beyond the scope of normal reclamation planning. An integrated approach is possible, but will not be considered herein. The Kuskulana Trail exhibits a complicated set of impacts brought on by road development and trail use. Continued trail use by pedestrian, horse, and vehicular means will increase the problem and prevent successful reclamation or restoration.

Each of the sites will be presented separately in order to facilitate the independent evaluation of each site. The experimental mine reclamation plan and associated monitoring program for each site are presented in Section 2.0 and 3.0, respectively.

2.1 LOWER GLEN CREEK

2.1.1 SITE DESCRIPTION

This site encompasses eleven placer mine claims along the lower two miles of Glen Creek in the Kantishna Hills section of Denali National Park and Preserve (Figure 2.1-1). The Kantishna Hills region has experienced considerable placer mining activity since the discovery of gold there in 1903. In 1906 many miners left the area as the rich deposits in several areas, including Glen Creek, were found to be limited. Sporadic mining

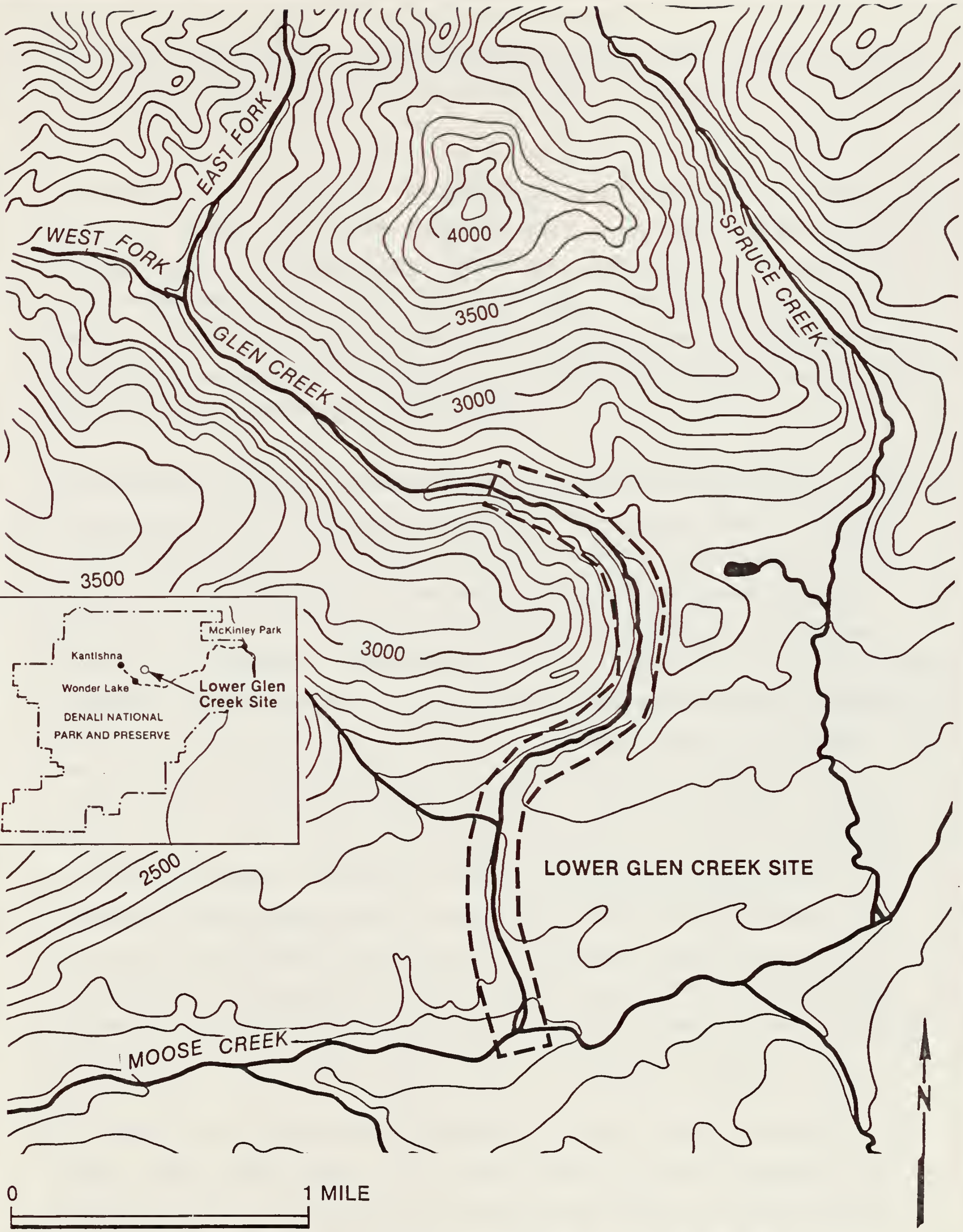

Figure 2.1-1
CONTOUR MAP OF LOWER GLEN CREEK SITE AND VICINITY

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on a much reduced scale has continued since that time. Intensive mining with heavy equipment was not employed on Glen Creek until the late 1960's (Deschu, 1984).

Elevations on the site range between 2,100 and 2,600 feet (ft) above mean sea level (msl). Glen Creek flows generally south from the Kantishna Hills to join with Moose Creek. The upper reaches of the Creek are in a confined channel with extensive gravel pockets and areas of exposed bedrock. The lower mile of Glen Creek occupies a less confined channel through a broad gravel bed. The stream gradient throughout the lower two miles (mi)is approximately 200 feet/mile.

The Kantishna Hills are located within the Kantishna River basin, a 6,770 square mile (sq mi) watershed tributary to the Tanana River. Streams such as Glen Creek which enter the system from the Kantishna Hills are fed by clear waters derived from rain, snowmelt, and ground water. Because of the area's isolation from glacier drainage, the Kantishna Hills are an important clear water source for the region. The Glen Creek watershed is approximately 5.4 sq mi and has an average annual discharge of 8.1 cubic feet per second (ft^3/sec). Discharge rates are variable and the average maximum flow is 108 ft^3/sec. Under natural conditions, surface waters in the Kantishna Hills are of good or excellent quality. Small streams from steep, well drained valleys are clear, fast-flowing, and well oxygenated. Turbidity levels in Glen Creek, however, are sometimes high, probably due to the active placer mine operations upstream from the Lower Glen Creek site (National Park Service, 1981). The average stream gradient of lower Glen Creek is only 33 meters per kilometers (m/km) which is comparable to other streams in the area which have meanders and numerous pools (Meyer and Kavanagh, 1983).

The study site is within the continental climatic zone of interior Alaska. The Alaska Range to the south blocks air mass movements which result in lower wind speeds and reduced precipitation on the leeward side. This zone is characterized by light precipitation and extreme annual variations in temperature. Precipitation averages 20.3 inches/year, half of it occurring from June through September. Snow

accumulations are generally between 20 and 30 inches (in), but may reach 60 in. January is the coldest month with an average mean temperature of -22°F. July, the warmest month, has an average mean monthly temperature of 52.7°F. Because of the high latitude, summer days are long and winter days short.

Soils in the area are Pergelic Cryaquepts which are common in loamy valley bottoms (SCS, 1977). These soils are poorly drained and the depth to ice-rich permafrost is greater than 2 ft. During the reconnaissance visit grab samples were collected from two spoil piles. The spoil material was loamy sand to sandy loam in texture and characterized by low conductivity (1 mmhos/cm), low organic matter (<1 percent), and low in available nutrients (nitrogen, phosphorus, and potassium). Results of soil analysis are presented in Table 2.1.

The Glen Creek site was situated in bottomland spruce-hardwood forest typical of the vegetation in interior Alaska forests. This vegetation occurred in well-drained bottomlands with the dominant species--white spruce (*Picea glauca*), willows (*Salix* spp), and balsam poplar (*Populus balsamifera*). The shrub community on the slopes of the Glen Creek was dominated by willows, alder (*Alnus crispa*), and blueberry (*Vaccinium* spp.).

The species which occurred in the area disturbed by mining activities along Glen Creek, are typical of early successional stages (Viereck & Little, 1972). These species included fireweed (*Epilobium latifolium*), feltleaf willow (*S. alaxensis*), alder, and forb species such as *Oxytropis campestris* and *Astragalus alpinus*. The vegetation at the Glen Creek site was primarily shrubs and forbs, but bluejoint reed grass (*Calamagrostis canadensis*) and red fescue (*Festuca rubra*) were present. In areas where vegetation was establishing on the spoil piles, white spruce seedlings (3 to 4 in high) were found.

A rich diversity of wildlife species inhabit the area. Moose, barren ground caribou, wolf, black bear, and grizzly bear are the largest of the inhabitants (Murie, 1962). Red fox, porcupine, least weasel, snowshoe

Table 2.1. Analysis of Soil Material Collected from the Three Reclamation Sites

Soil Parameters	Glen Creek[1]		Nelson/Radovan[2]	Kuskulana Trail		
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Texture	SnLo	LoSn	SnLo	Lo	Lo	Lo
pH (H_2O)	8.0	7.8	7.6	5.6	5.9	6.2
(buf)	7.0	7.0	7.0	6.8	7.0	7.0
CEC (me/100g)	8.6	5.8	0.8	0.3	0.2	0.3
Electrical Conductivity (mmhos/cm)	0.4	0.5	0.8	0.3	0.2	0.3
Sodium (meg/100g)	0.1	0.1	0.2	0.1	0.2	0.2
Organic Matter (%)	0.3	0.4	1.3	6.2	3.2	5.9
Nitrate-nitrogen (ppm)	6	4	27	3	3	3
Phosphorus (ppm)	1	1	9	8	4	12
Potassium (ppm)	20	15	90	40	25	35
Calcium (ppm)	800	500	3000	2000	1000	3000
Magnesium (ppm)	30	40	150	240	90	340
Boron (ppm)	0.3	0.4	1.6	0.6	0.4	0.4
Zinc (ppm)	0.4	1.1	0.6	2.5	0.6	1.6
Iron (ppm)	8.9	13.0	99	99	99	99
Manganese (ppm)	7.4	6.2	71.0	35.0	27.0	40.0
Copper (ppm)	0.4	0.7	6.3	3.5	2.6	14

Legend:

SnLo = Sandy Loam.
LoSn = Loamy Sand.
Lo = Loam.
meg/100g = milliequivalents per 100 grams.
mmhos/cm = micromhos per centimeter.
% = percent.
ppm = parts-per-million.

1 Samples represent disturbed soils from spoil piles.
2 Sample represents native soil collected from slope opposite the site.
3 Samples represent disturbed soils along the trail.

hare, hoary marmot, arctic ground squirrel, and a variety of smaller mammals are also present (Rearden, 1981). Although the habitat is not favorable for many bird species, several species of waterfowl, raptors, grouse, and songbirds also inhabit the general area (Armstrong, 1980; Meyers and Kavanagh, 1984; Quinlan et al., 1983). Tundra and forested areas along streams such as Glen Creek are preferred grizzly habitat, and caribou were observed on Glen Glen Creek within the study site during the site reconnaissance visit in August, 1985.

Two fish species have been reported from lower Glen Creek, arctic grayling (Thymallus arcticus) and the slimy sculpin (Cottus cognatus). In a total sampling of 5.18 km of lower Glen Creek, only three grayling and six slimy sculpins were observed, and all of these were from the lower kilometer of the stream (Meyers and Kavanagh, 1983). The presence of clear water, at least periodically (Simmons, 1984), is important to arctic grayling which spawn in small, cold, and clear streams such as Glen Creek which they reach by upstream migration during the early spring (Krueger, 1981).

The natural conditions and habitats described above are highly disturbed on the site as a result of mine access and operations over the past several decades. Much of the area has been disturbed, and the remains of mine operations are evident. This disturbance has created a number of reclamation problems which are characteristic of placer mining throughout much of Alaska, hence the implementation of an experimental reclamation plan for this area should produce findings which are generally applicable to past and current placer mine operations throughout Alaska.

2.1.2 RECLAMATION CONCERNS

Abandoned equipment, shelters, and mining debris are scattered over much of the site (Figure 2.1-2). These items must be removed from the site prior to other site reclamation activities.

In Alaska, placer mining increases turbidity, settlable solids, filterable and nonfilterable residues, and total metals (Bjerklie and La Perriere, 1985). Water resources on site are severely affected by

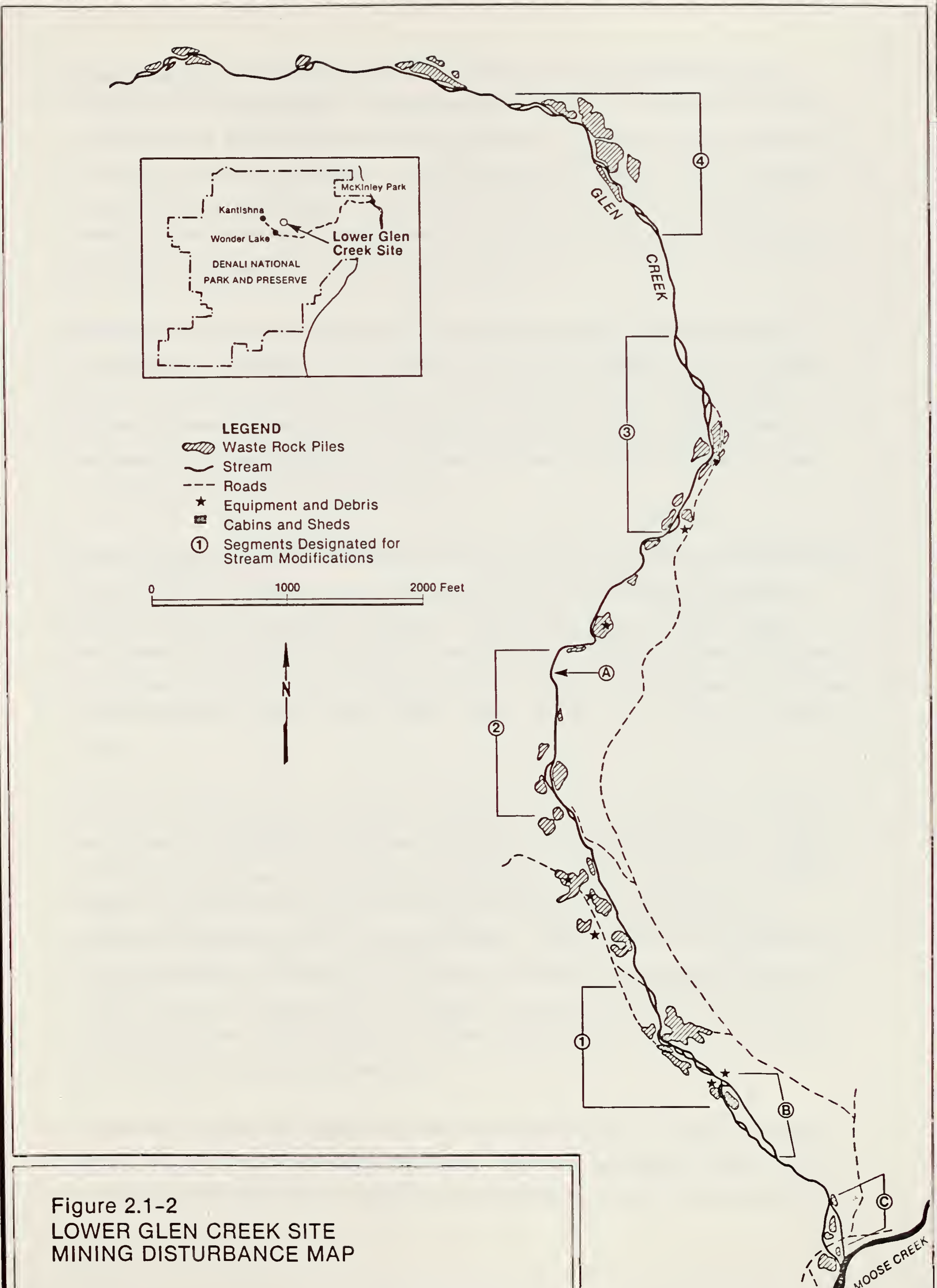

Figure 2.1-2
LOWER GLEN CREEK SITE
MINING DISTURBANCE MAP

placer mining. The most conspicuous effect is the introduction of sediment into Glen Creek. Stream waters become silt laden during mine operations in which the gold-bearing gravels are washed and the water is permitted to flow downstream. Overburden piles, waste rock (tailings), cleared areas, and access roads on and near the site are subject to erosion from snowmelt, rain storms, and stream cutting which contribute additional sediments to the stream channel.

Sedimentation and mine-related contamination spreads great distances downstream. Sediments in the waters affected by placer mining in Glen Creek affected the water quality of the lower Bear Paw River, almost 50 miles downstream (National Park Service, 1981). Deschu (1984) has documented the sedimentation problems on Glen Creek which result from past and present mining operations.

Placer mining can also increase ore-related heavy metals in stream waters (EPA, 1976). The metals are associated with non-dissolved inorganic minerals in the suspended sediment. LaPerriere et al. (1985) found increases in arsenic, lead, zinc, and copper in Alaska streams affected by placer mining. Arsenic is known to be a potential problem for streams in the Kantishna Hills (EPA, 1980). This may also be a problem on Glen Creek.

Piles of mechanically sorted and unsorted waste rock up to 20 feet high are present throughout the lower Glen Creek site (Figure 2.1-2). These piles are sometimes called tailings, however the term tailings properly refers to waste material which has been subjected to mechanical or chemical degradation in a milling process. These piles are inconsistent with the natural surrounding contours, are slow to revegetate because of their increased exposure and drainage, and are frequently eroded by the shifting stream. The erosion of these piles increases stream turbidity and compaction of stream gravels.

Bottom siltation and compaction are long-term impacts of placer mining which are evident throughout the site. Streams continue to pick up and move bottom sediments and erode spoil piles long after the cessation of

mining operations. Silt particles can scour the streambed and severely affect or destroy bottom-dwelling aquatic life.

Placer mine sedimentation has also adversely affected fish habitat in the creek. Stream sedimentation and the resulting compaction of gravels renders the habitat unsuitable for spawning by arctic grayling (Alaska Department of Fish and Game, 1981 and 1983). Simmons (1984) conducted studies on the effects of placer mining on arctic grayling and found that grayling avoided streams carrying mine sediments. In experiments using caged fish, grayling in mined streams suffered chronic effects including gill damage, dietary deficiencies, and slowed maturation. He concluded that the indirect effects of sedimentation through loss of summer habitat for feeding and reproduction are more severe than the direct ones.

The relocation and loss of soils is another noticeable impact of placer mining. The induced instability of soil is an important impact noted on steep banks onsite. During gravel sorting operations much of the soil material is lost from the sorted materials. The piles of coarse rock cannot revegetate until sufficient soil material is present, and the finer materials have been lost into the stream channel where they result in sedimentation problems already discussed.

Many of the gravel piles on the lower Glen Creek site are unsorted and contain substantial amounts of soil. Some of the older piles are in the process of revegetating naturally from surrounding areas, however, the steep slopes and exposure to stream cutting make most of the piles onsite unsuited to revegetation in their present condition and/or location. These piles present problems because of their visual inconsistency with the surrounding topography, their steep slopes permit increased water flow leading to erosion and excessive drying of the soil which prevents or delays the establishment of new vegetation, and they create a generally unstable condition susceptible to water and wind erosion.

The clearing of plant cover during mining operations has produced soil instability, loss of habitat for wildlife, direct loss of vegetation, and has a pronounced adverse visual impact. Clearing of vegetation for roads

can add approximately two acres per linear mile of mine-related impact. The lower Glen Creek site contains large areas of exposed and minimally revegetated surface materials. Recontouring of these areas will be necessary to provide suitable conditions for revegetation, reduce visual impact, increase soil surface stability, reduce erosion/sedimentation effects, and define and stabilize the stream channel. The redistribution of soils must occur in an orderly pattern to reduce the introduction of additional impacts such as stream sedimentation and removal of additional vegetation.

Mining activities can have substantial and long term impacts on wildlife. Access roads may affect animal movements (e.g., caribou migration patterns). Removal of willows and other streamside vegetation reduces available moose habitat (Kertel, 1984). Noise, poaching, and general habitat disturbance are secondary effects of mining brought about by increased access and human presence in mining areas. These factors can disturb nesting raptors, reducing their breeding numbers and adversely affecting their population. Reclamation of mines and associated access roads can reduce the cumulative impacts of these activities and eliminate the long term effects of mining.

Stream restoration is a major consideration of reclamation planning. Hydrologic systems are considerably altered in terms of drainage patterns, sedimentation, and habitat for aquatic biota as a result of this form of mining (Madison, 1981). The lower Glen Creek site exhibits many problems which characterize other placer mined streams throughout Alaska. As a result of past mining operations, the channel is poorly defined, streambank and spoil pile erosion occurs at several locations, an access road traverses portions of the stream channel, the stream bottom is compacted with sediments, and fish habitats (e.g., pools, riffles, and undercut stabilized streambanks) are limited in extent. Reclamation planning must address each of these considerations.

The Alaska Department of Fish and Game has recently developed best management practices guides for placer mining in Alaska (Entrix, 1986a and 1986b). These documents provide recommendations for developing mine

plans, controlling point and nonpoint source pollution of streams, and for mine site rehabilitation. The detailed information on stream channel restoration, recontouring, and revegetation guidelines involves conditions which occur on operating mine sites. While these recommendations are appropriate and helpful to operating mines outside national parks, only portions of the specific suggestions can be used within the parks. The currently acceptable practice of stockpiling organic debris for use in post-mining reclamation stockpiled by operating mines as disturbance progresses is limited on the abandoned claims along lower Glen Creek. Stream stabilization using riprap, concrete, tile pipes, etc. may work well, but these structures are inappropriate for natural restoration of mined lands within national parks. However, the portions of these documents which concern construction of settling ponds, restoration of stream meander pattern, and recontouring are pertinent to reclamation on the lower Glen Creek site.

2.1.3 RECONTOURING AND REVEGETATION

The objectives of the proposed reclamation plan for the Glen Creek site include:

- Restoration of the entire area disturbed by placer mining including creek channel, adjacent waste rock areas, and onsite access roads. This assumes that reclamation is desired in spite of active mining upstream of the site and that the use of the streambed as a road will be discontinued;
- Reestablishment of a native plant community. Emphasis will be on use of plant materials from the local area. Long term reclamation will be natural and not dependent on extreme maintenance and management; and
- Experimentation with state-of-the-art reclamation techniques emphasizing natural revegetation and limited management.

Because of the earth-moving required to recontour the waste rock piles and to rechannel the stream bed, restoration of Glen Creek may be phased. Recontouring should be initiated upstream to minimize impacts and avoid duplication of efforts.

2.1.3.1 Structure and Equipment Removal

The first reclamation task will be to remove all equipment, manmade structures, and surface debris from the area. The lower Glen Creek site is within the Kantishna Hills historical mining district. Surveys of the area however, indicate that no structures of historical significance which should be preserved occur within the lower Glen Creek study area (National Park Service, 1981).

A salvage contractor should be retained to remove all equipment and debris (including the camp) prior to reclamation activities. Items requiring salvage include separators, sluice boxes, water tanks, drums, bins, an abandoned trailer, sheds, and miscellaneous mine-related materials. The location of major items is shown on Figure 2.1-2.

2.1.3.2 Site Preparation

Piles of waste rock along Glen Creek will be recontoured to slopes of 3:1 or less depending on available area to place the spoil material. These materials will be placed away from the stream channel and against the adjoining slopes to reduce bank and pile erosion and sedimentation to the stream. A reclamation supervisor will be onsite during recontouring to direct the actual placement of each spoil pile since it is advantageous to use the coarser materials in or alongside sections of the stream channel. Fine particle material (silt), where available, will be used as topsoil material to provide a more desirable plant growth medium. Final placement of each pile will be determined as actual reclamation activities are implemented.

Where available, fine-particle material will be placed over the coarser spoils to a depth of 6 to 8 inches. As indicated earlier (Holmes, 1982), presence of silt material was the most important factor affecting revegetation success on tailings near Fox, Alaska. Therefore, available fines will be used as topsoil for as much of the area as possible. One spoil pile was identified during the site visit as suitable topsoil material. An onsite revegetation supervisor may locate additional suitable material as the recontouring progresses. Dredging and sorting of the stream channel may also provide fine-particle material. After

placement of the topsoil, the area should be lightly compacted to provide a firm seedbed. The seedbed should be in a roughbed condition to enhance seed germination and moisture infiltration and to reduce erosion. In areas where fines are not available, additional compaction of the coarse material should be done to improve moisture retention (Holmes, 1982).

2.1.3.3 Plant Materials

Early successional plant species are often successful when used in reclamation studies (Hernandez, 1973) since they are well-adapted to existing conditions. Reconnaissance of the Glen Creek site indicated the feltleaf willow, alder, forbs, and several grass species were the early colonizers. Revegetation of Glen Creek will be primarily achieved by:

- Willow cuttings from adjacent areas; and
- Woody species transplant trials.

Feltleaf willow is the primary colonizer in the area. Cuttings (the upper 10 to 14 in of shoots; basal cut immediately below the node) will be collected in March or April, while willows are dormant. Cuttings will be tied in bundles maintaining stem polarity and wrapped at the base with a wet paper towel. These will be stored in plastic bags in the freezer until planting. In late May or early June, planting will be done allowing no more than one day after the cuttings are removed from the freezer. Cuttings will be pushed into the ground so that only one to two in of cuttings remains above the surface. The proximal end will be dipped, prior to planting, in a solution of indolebutyric acid (IBA) to promote root formation. Cuttings will be planted at 5 x 5 foot spacings.

Feltleaf willow will be the species tested in the experimental plots. Other willow species (*Salix glauca*, *S. barclayi*, *S. bebbiana*, *S. scouleriana*) are suitable for revegetation (Alaska Rural Development Council, 1983) and can be included randomly in other areas to be reclaimed. As species are included they could be clearly marked so their success can be monitored. The cutting method for feltleaf willow should be employed for other willow species.

Transplants of local woody plant species will be used to revegetate areas along disturbed slopes and distant to the stream channel. Species suitable for transplants include: white spruce, balsam poplar, American green alder, dwarf arctic birch (*Betula nana*), narrow-leaf Labrador tea (*Ledum decumbens*), American red currant (*Ribes triste*), bog blueberry (*Vaccinium uliginosum*), and mountain cranberry (*Vaccinium vitis-idaea*) (Alaska Rural Development Council, 1983).

Transplants should be planted in natural groups at spacing of 5 x 5 feet for spruce, poplar, alder, birch and Labrador-tea. Remaining species should be planted at 2 x 2 foot spacing. Individual plants should be selected which are small enough to allow the entire root system to be transplanted. Therefore 6 to 12 in plants are recommended. Care should be taken so that the soil around the roots is not disturbed. This will reduce damage and desiccation effects. After planting, the soil around the individual plant roots will be firmly packed to remove any air pockets. Records will be maintained regarding the species and number of individual transplants so that survival rates can be monitored.

2.1.3.4 Fertilizer

Disturbed soils are typically nutrient poor. Fertilizer has the demonstrated ability to enhance vegetative establishment and survival (Hernandez, 1973; Densmore, 1977). Commercially available fertilizers are sufficient and cost effective (Kubanis, 1982). A chemical fertilizer (8-32-16) will be applied to all disturbed sites at a rate of 300 pounds per acre. Fertilizer will be broadcast in the spring after planting. Plots will be designed and amounts will be small in order to prevent fertilizer from adversely affecting the water quality at Glen Creek.

2.1.4 STREAM CHANNEL RESTORATION

Montane alluvial streams such as Glen Creek are the most actively changing of all geomorphic forms (Hasfurther, 1985). It is the rule rather than the exception that banks will erode, sediments will be deposited, and channels will change with time. Most streams are continually changing in shape and position as a consequence of hydraulic forces acting on their beds and banks. Thus, in planning for stream

restoration, it is desirable to create a range of appropriate stream channel features which will allow the stream to respond quickly to natural forces. The result of stream reclamation should be a hydrologically stabilized channel with controlled sediment deposition and transport, and with flow charactersitics and substrate modifications adequate for the reestablishment of aquatic biota.

Unlike terrestrial reclamation in which new plants and animals are introduced into formerly disturbed areas, stream reclamation projects entail the design and placement of suitable habitat structures for invading pioneer and colonizing species. In essence, stream restoration is the implementation of recovery enhancement (Gore, 1985). The need to restore appropriate stream depths and velocities is fundamental, but channel roughness is even more critical to fish populations (Wesche, 1985). Numerous physical and biological factors contribute to roughness. Those that enhance habitat diversity include:

- Channel configuration;
- Substrate type;
- Bank composition;
- Bank type;
- Bank configuration;
- Aquatic vegetation;
- Riparian vegetation; and
- Snags.

There are two basic approaches to stream restoration. One emphasizes watershed reclamation through enhancement of vegetative cover while the other focuses on instream habitat restoration. Because disturbance due to placer mining results in extensive disturbance to the stream channel proper, stream restoration activites at the lower Glen Creek site will concentrate on stream channel modification and restoration of instream habitat. Those methods which are applicable to Glen Creek and similar placer-mined streams include:

- Overall channel design (including substrate manipulation, creating meanders, restoring pools and riffle areas);
- Bank stabilization;

- o Enhancement of water quality;
- o Installation of in-channel structures; and
- o Riparian management and enhancement.

Different combinations of these general approaches will be used as appropriate for the reclamation of segments of lower Glen Creek, only after sediment input from upstream mining operations have ceased or been controlled, and following the elimination of continued disturbance from vehicular traffic within the lower Glen Creek site.

Placer mining operations along lower Glen Creek have caused significant modifications of the original channel and have substantially altered the original stream characteristics. Pool and riffle areas are largely absent due to the removal and rearrangement of boulders and gravels throughout most of the extent of the site during sluicing and separating operations. Gravel and cobbles in the streambed have become embedded as a result of sedimentation from past and present mining disturbance and from the continued erosion of tailings piles adjacent to the stream channel on site. The situation is compounded by the movement of vehicles and mining equipment through the stream channel and by the sediment input from upstream mining operations (Deschu, 1984).

The stream channel within the site has undergone substantial changes from its original condition as a consequence of past onsite mining activities and current upstream mining operations. The streambed of Glen Creek is presently characterized by an embedded substrate of cobbles, gravel, and silt. The stream has numerous shallow braided segments (Figure 2.1-2) which are not typical of adjacent streams which have not been mined, and pool areas are almost entirely absent. The resulting situation has reduced habitat for benthic organisms and fish species which inhabit Glen Creek.

2.1.4.1 Stream Pattern Restoration

Although segments of the site will be set aside for experimental reclamation, the streambed throughout the site must be stabilized to ensure hydrological stability, reduce bank erosion to natural levels, and

restore substrate diversity. Channel modification activities will be coordinated with general site recontouring. Both activities will be supervised by an onsite reclamation specialist to ensure proper placement of boulders, logs, and other instream and streambank structures. Areas of the stream channel identified as requiring particular attention include areas adjacent to eroding tailings piles, shallow braided segments, and areas flowing over exposed bedrock. Recontouring and channel restoration will begin at the uppermost part of the site and progress downstream so that successively restored areas will not adversely affect those which have already been reclaimed.

Streambed modification and recontouring adjacent to the stream channel will create a substantial sedimentation problem. Settling ponds will be established in the vicinity of the four stream segments designated for major stream modification (Figure 2.1-3). In order to minimize the impact of restoration and to reduce the total amount of recontouring, ponds will be located in areas of existing disturbance.

The Alaska Power Authority provides pertinent guidance on the construction and use of settling ponds to remove sediments generated during stream disturbance activities in its Best Management Practices Manual for Erosion and Sedimentation Control (1985). Each settling pond will consist of a dike, a pit, and an outlet for clean water. Factors such as pond surface area, rate of flow through the pond, sediment grain size, water temperature, turbulence, and entrance/exit configuration will be considered during the construction of each pond. Onsite analysis will be needed to determine the locations of settling ponds.

Settling ponds will be sized so that the effluent is in conformance with Alaska Water Quality Standards. Pond configuration and final design characteristics will comply with guidance provided in the Best Management Practices Manual for Erosion and Sedimentation Control (Alaska Power Authority, 1985) for construction and use of sedimentation ponds. Removal of suspended particles larger than 0.02 mm are usually necessary to meet this limitation. The maximum overflow rate (flow rate through the pond divided by the surface area of the pond) to permit sedimentation

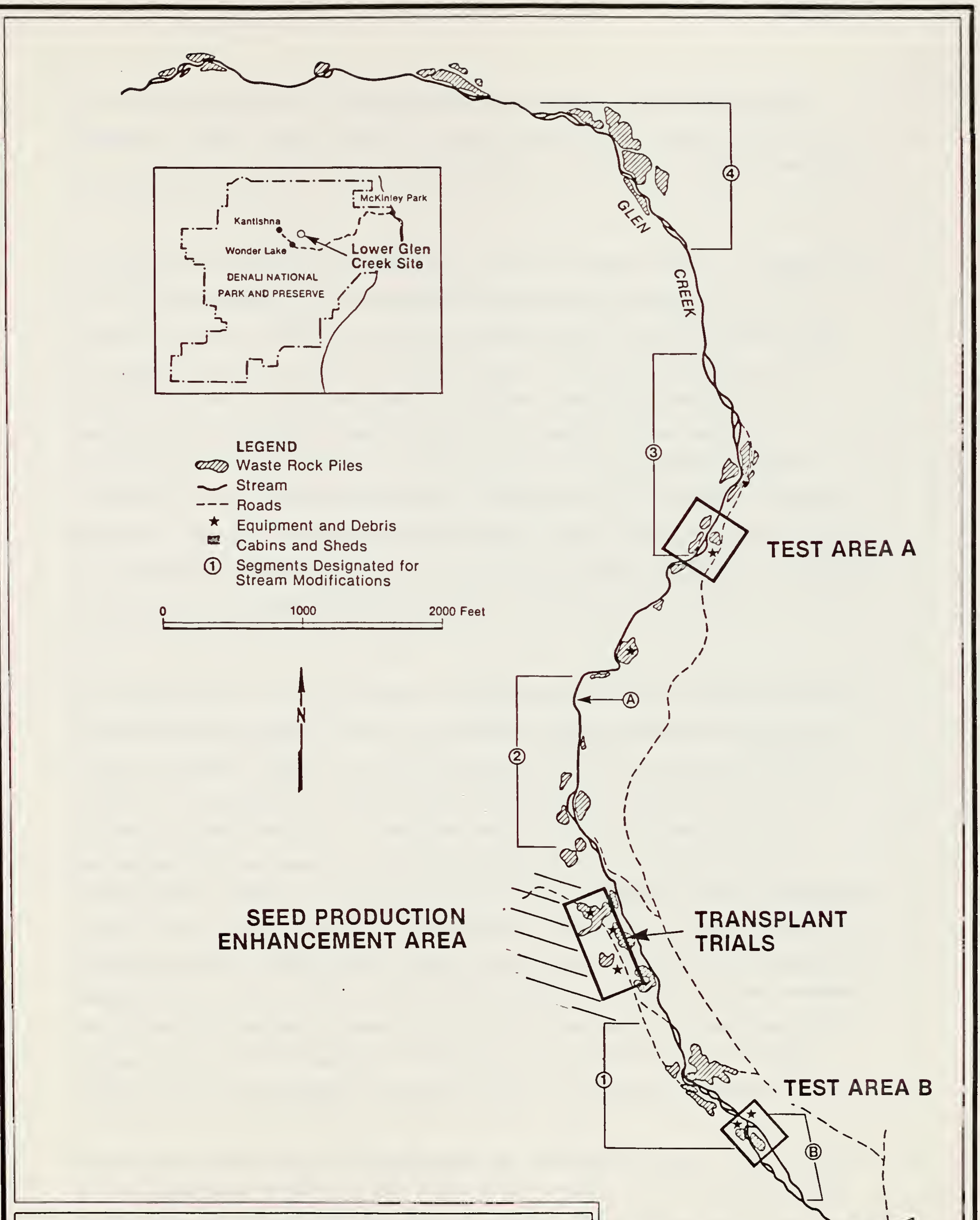

Figure 2.1-3
LOWER GLEN CREEK RECLAMATION AREAS

of 0.02 mm particles is 3,700 gal per minute per acre (Alaska Power Authority, 1985). Ponds will be constructed with a length that is at least twice the width. Where circumstances permit, the length-to-width ratio will be 5:1.

Containment dikes for settling ponds will not exceed 10 ft in height and will be constructed with upstream and downstream slopes of 2:1 or flatter. Outlet structures will be constructed as overflow spillways. The width of the overflow will be at least 1 ft for each 400 gal per minute of flow through each pond. Effuent from each pond will be monitored daily with an Imhoff cone to determine if the pond is effectively removing sediments. At the end of stream modification activities for a particular segment, sediments will be removed from the ponds and tested for the presence of heavy metals prior to distribution over recontoured tailings areas in order to enhance revegetation efforts. At the end of stream modification and recontouring activities, all ponds will be drained and recontoured.

The major focus of stream pattern restoration will be to remove shallow braided stream segments and create meanders approximating those which exist in nearby streams in the Kantishna Hills (e.g., Spruce Creek) and similar to the pattern which probably existed in Glen Creek prior to intensive placer mining. A meander analysis will be conducted to determine the fundamental wavelength, mean radius of curvature, and meander belt width in areas determined to be reasonably free of geologic control such as are present in the lower 5,000 ft of the Glen Creek stream channel. The basis of this methodology is to perform a basinwide analysis of at least three undisturbed stream reaches on nearby streams with similar gradients, substrate, and flow rates (e.g., portions of Spruce Creek). The radius of curvature used to restore the stream channel should approximate the mean value for the areas sampled.

Due to the relatively steep gradient and confined channel, particularly in the upstream portion of the lower Glen Creek site, the meander belt width will be narrow and the pattern simple. Configuration of the stream pattern in most of the upper portion of the site (above point A on

Figure 2.1-3) is controlled by geologic features including steep adjacent slopes and outcrops of underlying bedrock. Stream channel modification in this area will involve stabilization of the bank, restoration of pools and cutbanks stabilized with logs and boulders, and placement of gravel and large cobbles to provide suitable substrate for stream benthos and spawning/resting habitat for arctic grayling which inhabit the creek. The stream pattern will be changed to remove braided areas and confine the stream to a single deeper channel with pools and riffle areas at appropriate locations.

The stream pattern in the lower half of the site is less confined by slopes as the stream passes over broad expanses of alluvial materials. Large tailings piles are being eroded by the stream at several locations, and the stream assumes a braided appearance with a shallow cross section at several locations in this stretch. The channel through the downstream section of the site will be kept away from the base of valley slopes to prevent excessive cutbank erosion and stream sedimentation. The large waste rock piles throughout this area (Figure 2.1-3) will be recontoured to enhance revegetation and to prevent slumping into the stream channel. Sand and silt bars along the lower mile of Glen Creek will be removed and placed on recontoured tailings piles to enhance revegetation and to prevent them from adding sediment to the creek.

Cleaning the streambed substrate to remove fine sediments will be necessary to restore fish spawning areas and provide habitat for benthic macroinvertebrates. The Washington Department of Fisheries has developed methods which successfully restore spawning salmon habitat by reducing the concentrations of fine sediments by using a bulldozer (Reeves and Roelofs, 1982). The procedure consists of plowing through the streambed at approximately a 45 degree angle to overturn the gravel, then moving downstream in a succession of similar moves, allowing the gravel to be cleaned as the stream channel is restored (Figure 2.1-4). This approach will be used for channel restoration at Glen Creek.

Stream braiding occurs at several locations within the lower Glen Creek site. Minor side channels in the lower part of the site (B and C on

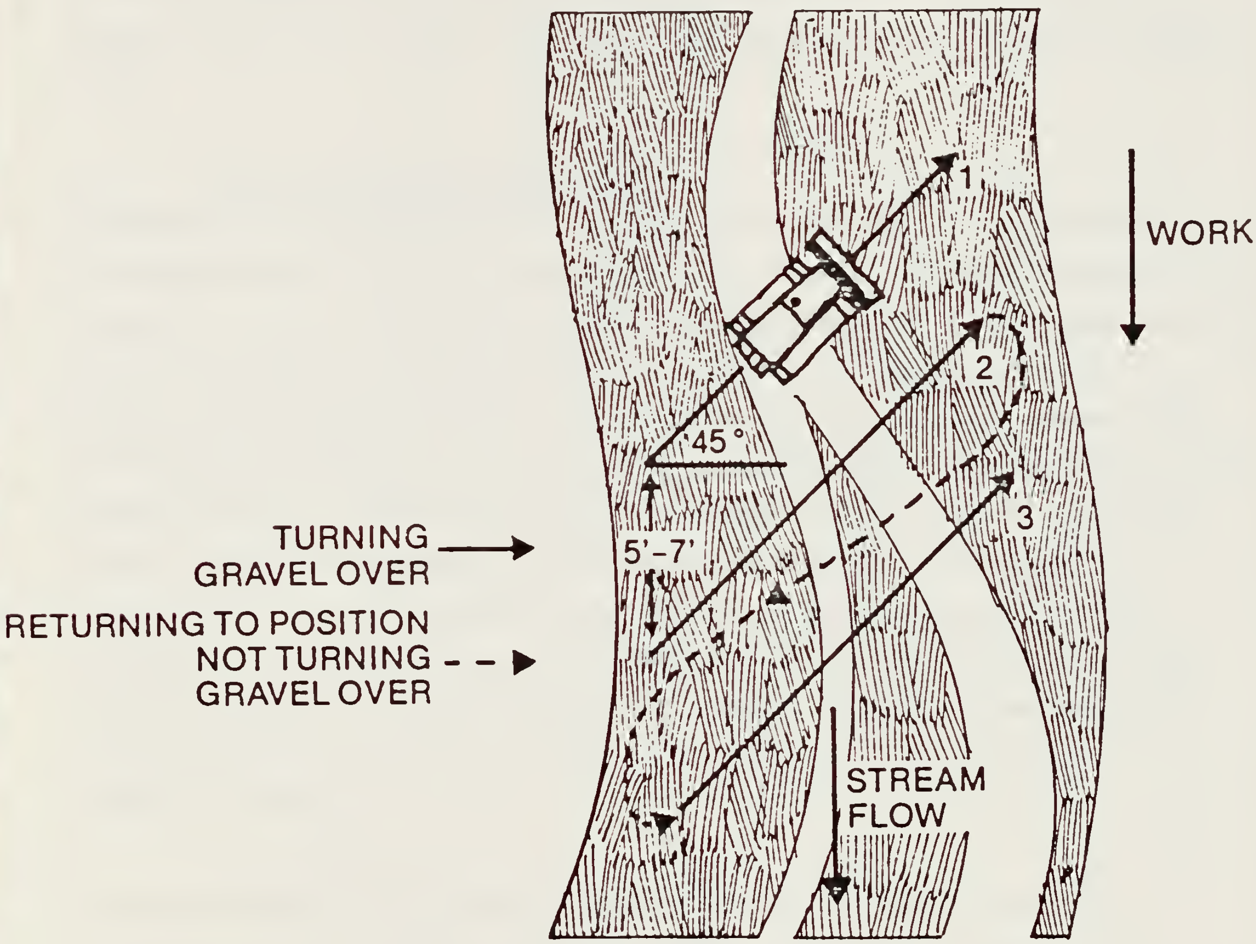

Figure 2.1-4
CLEANING STREAMBED GRAVEL BY BULLDOZER

SOURCE: REEVES & ROELOFS, 1982

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Figure 2.1-3) will be closed with tailings from nearby piles. A barrier of large rocks will be placed along this point on the remaining stream to prevent erosion of the area and reopening of this channel. The shallow channel will then be filled with waste rock from nearby piles and prepared to enhance revegetation (see Section 2.1.3.2). Braided areas farther upstream will require extensive modification to restore the meander pattern and create suitable fish habitat while avoiding sediment input.

2.1.4.2 Aquatic Habitat Restoration

Restoration of stream pattern (Section 2.1.4.1) must be implemented in conjunction with habitat restoration activities to achieve reclamation of lower Glen Creek. The four fundamental components of fish habitat which must be considered during stream restoration are acceptable water quality, food-producing areas, spawning areas, and cover. Removal of tailings piles adjacent to the active stream channel, restoration of the meander pattern, and deepening of the channel will create a relatively stable channel environment and improve water quality. Removal of artificially created barriers, extraction of silt and sand from the streambed, and installation of erosion prevention features along steep banks will further restore the stream channel. However, many habitat features which are suitable for fish will not be present without additional effort.

Stream management to increase fish production involves a variety of techniques and structures, many of which increase populations above normal levels, are unnatural in appearance, and may be costly to install. The objective of aquatic habitat restoration on lower Glen Creek is to enhance the recovery of this highly modified stream to its former undisturbed state, and not simply to increase fish productivity. Therefore, restoration of fish habitat will employ the use of natural, onsite materials but will not involve the use or construction of dams, gambions, riprap, and other such complex and artificial structures.

Surveys conducted in the Kantishna Hills revealed that Glen Creek is inhabited by Slimy Scuplin (*Cottus cognatus*) and arctic grayling (*Thymallus arcticus*). The Slimy Sculpin is widely distributed all across

North America and is abundant throughout its range (Morrow, 1980). Arctic grayling are more restricted in their range and inhabit clear cold water streams with gravel bottoms. Simmons (1984) found that arctic grayling generally avoided streams affected by placer mining, and that caged fish placed in streams carrying mine sediments suffered direct chronic effects including gill damage, dietary deficiencies, and slowed maturation. Sedimentation from placer mining causes additional habitat deterioration by creating an embedded substrate which reduces habitat for benthic macroinvertebrates and other stream organisms (Gore, 1985) which serve as food for both arctic grayling and sculpin. Stream sediments also fill cavities in the gravel which would otherwise provide spawning areas for arctic grayling.

Cutbanks, pools, and overhangs provide necessary cover for fish and additional habitat for their prey (Krueger, 1981; Lister et al., 1980). Cutbanks and pools will be created along the outside of stream bends and below bedrock outcrops in the restored stream channel (Figure 2.1-5). Dead but sturdy logs collected on or near the site will be embedded in the side of the stream channel and anchored at each end with large rocks from the streambed. The area behind the logs will be filled to water level with large rocks for support and topped with a layer of biodegradable fabric such as burlap to hold the layer of soil (silt and gravel sediment) placed above it. This area and the adjacent streambank will be revegetated with willow cuttings to provide cover and stabilize the bank as the fabric and logs eventually deteriorate.

Smaller pools will be developed in open channel areas using some of the larger boulders to maintain small pools for fish cover. Boulders will be selectively placed singly and in groups to provide scour pools (Figure 2.1-6). Placement will be done during low flows to assure proper location and facilitate movement of heavy equipment in the channel. Boulders will be embedded a short distance into the streambed to provide stability and will be oriented with a slight overhang downstream to enhance pool formation (Wesche, 1985; Lister, 1980). Boulders and boulder clusters will be located toward the outside of the stream curve to minimize bedload deposition.

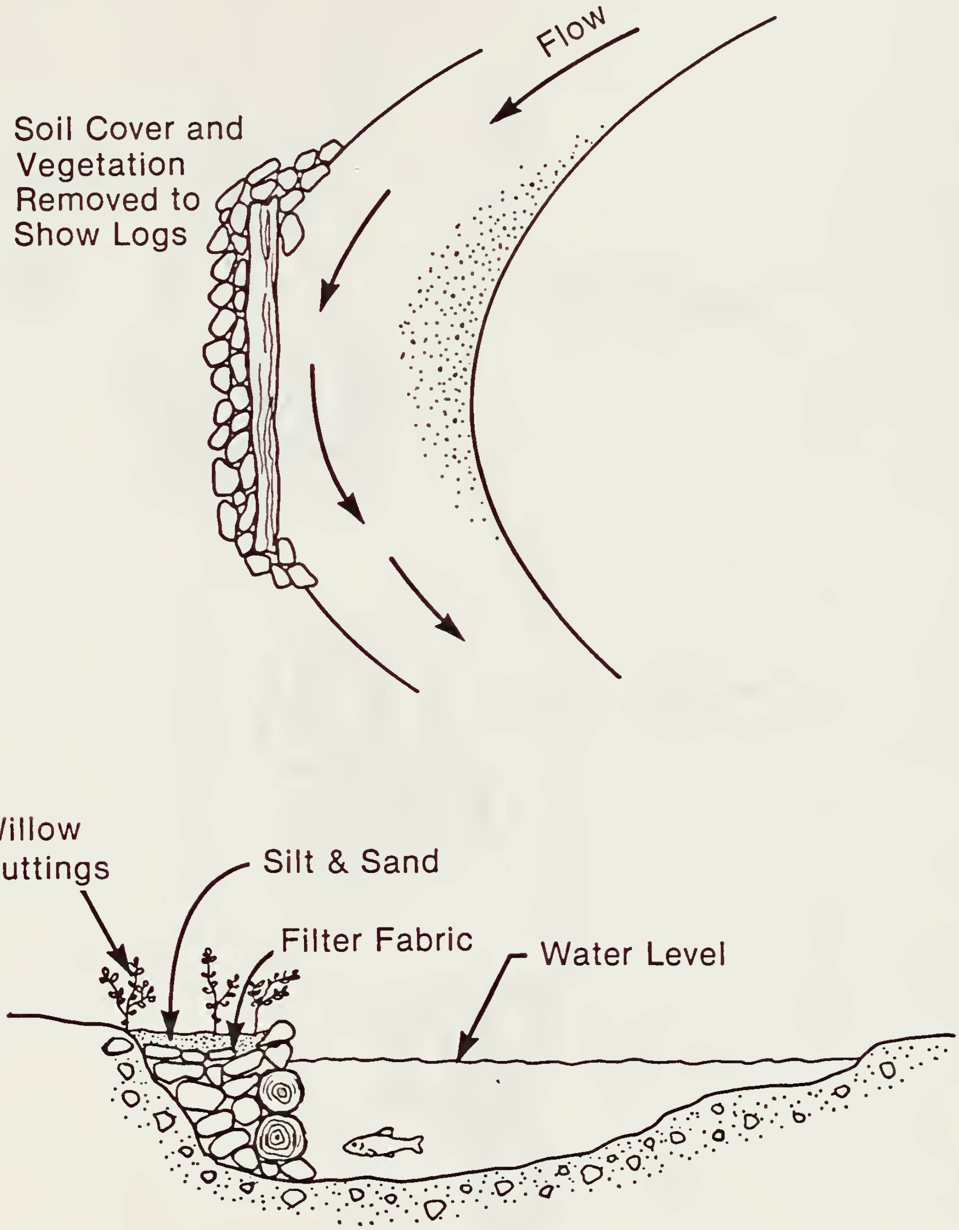

Figure 2.1-5
CUTBANK AND POOL CREATED FROM ONSITE LOGS AND ROCKS.
SEE TEXT FOR EXPLANATION
SOURCE: LISTER, 1980

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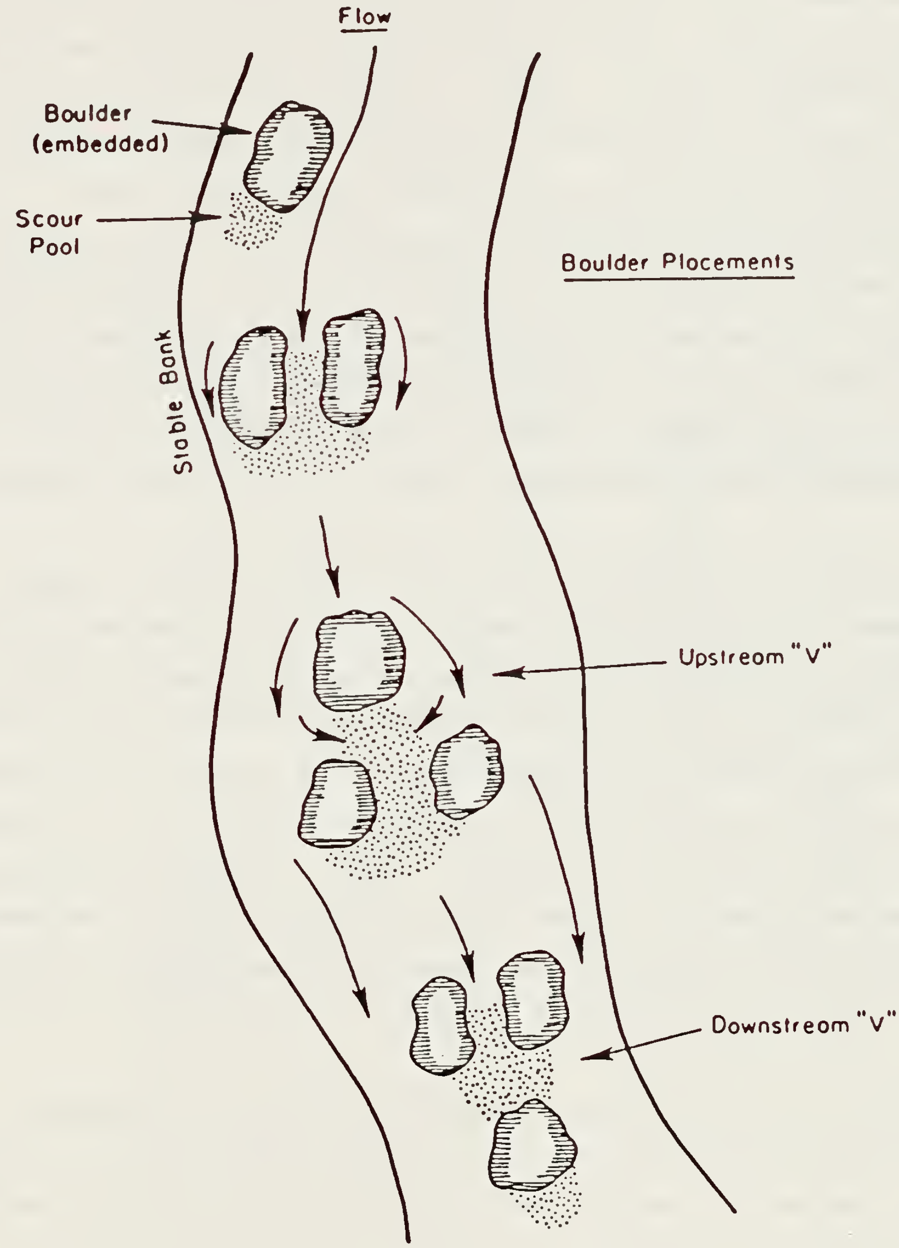

Figure 2.1-6
TYPICAL BOULDER PLACEMENT SCHEMES TO ENHANCE FISH HABITAT
SOURCE: WESCHE, 1985

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Wing deflectors will be built using natural streambed materials and will be designed to appear as naturally occurring stream features. Properly placed, wing deflectors direct stream flow against the opposite bank, promoting bank undercutting and bed scour which in turn enhance habitat for macroinvertebrates and fish (Burgess, 1985). Deflectors will be installed at angles of 30 degrees or less to prevent impoundment of water upstream and to conform to the natural configuration of the stream channel. Large rocks will be used in the construction of the deflectors to minimize erosion of the deflector and scouring of the adjacent bank. The wing deflectors will be constructed of two layers of rock, the lower of which is embedded in the stream channel and the upper situated to be below water level under high flow conditions. Because of the coarse composition of streambed materials, some pool excavation will be required to speed the natural erosion process and develop suitable habitat.

Logs, stumps, and dead trees from the site will also be used to temporarily enhance fish habitat. These materials will be combined with construction of bank revetments, cutbanks, and boulders to enhance recovery of the stream biota (Figure 2.1-7). The use of these materials to stabilize the stream channel and enhance fish habitat has been encouraged by the Alaska Department of Fish and Game (P. Weber, personal communication, August 29, 1985). Strategic location of these improvements will add stability to the channel, allowing natural stream development to occur and also hastening the return of substantial resident fish populations to the lower portions of Glen Creek.

Proper installation of stream enhancement structures (e.g., larger boulders, wing deflectors, logs, dead trees, etc.) will require onsite decisions for selection of materials and placement of objects along the channel in conjunction with stream pattern restoration and revegetation activities. Some hand labor will be required in addition to the use of heavy equipment to situate and install these features. Once installed, these structures will not require maintenance.

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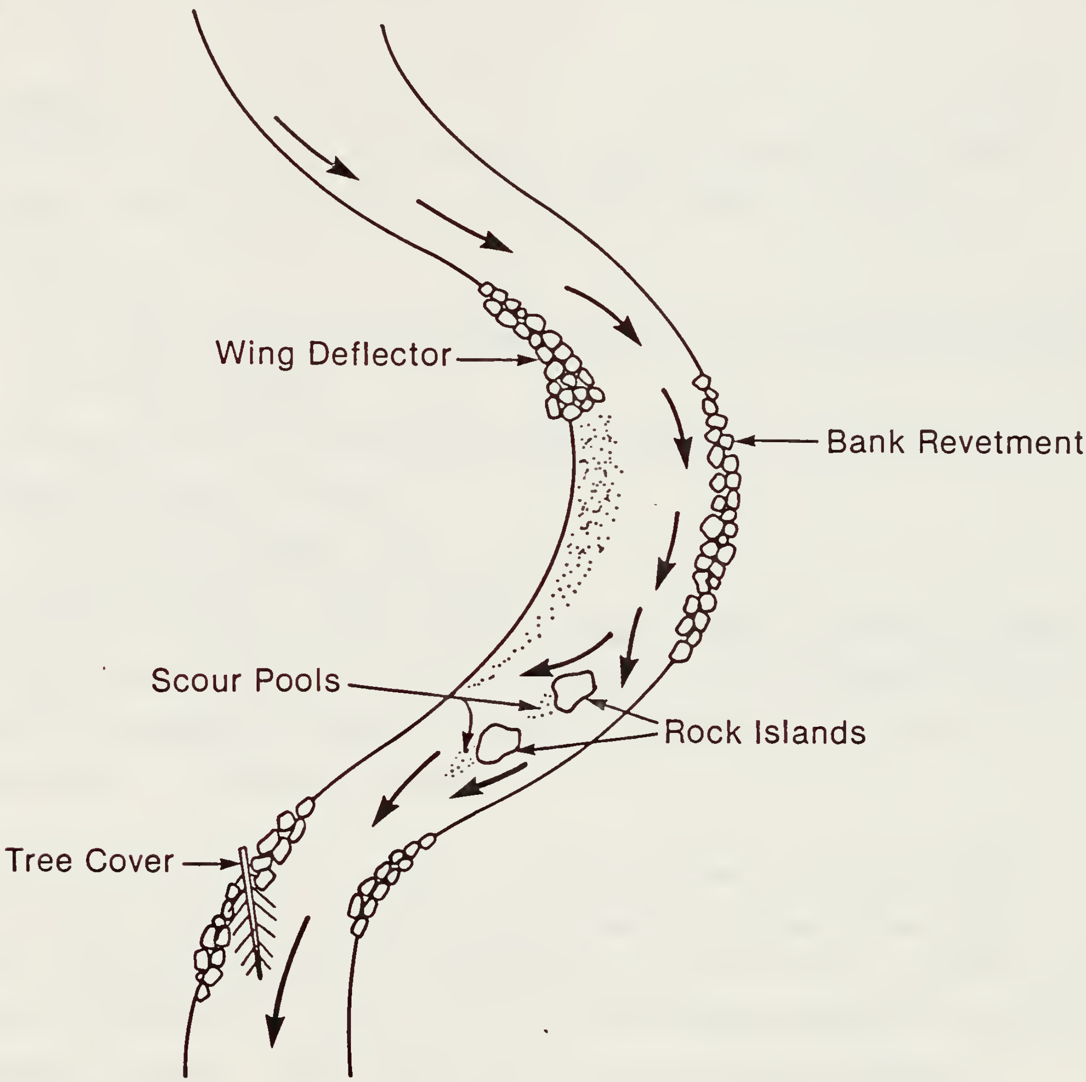

Figure 2.1-7
STREAM ENHANCEMENT TECHNIQUES
FOR LOWER GLEN CREEK
SOURCE: WHITE AND BRYNILDSON, 1967

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2.1.5 EXPERIMENTAL DESIGN

Experimental tests along Glenn Creek will consist of two test areas (A and B) plus an area for woody plant transplant trials (Figure 2.1-3). Areas not used for experimental research will be revegetated as described above.

Test Area A

Two variables will be tested at Area A: surface material and willow cuttings. The surface material variable will consist of three treatments:

S_1 = Fines;

S_2 = Coarse material covered with 6 to 8 in of fines material; and

S_3 = Coarse material.

The test with willow cuttings will compare natural revegetation to plantings of willow cuttings:

P_1 = Willow cuttings; and

P_2 = No willow cuttings (control).

Applicaton of P_1 and P_2 will be done randomly. The experimental design for these treatments is presented in Figure 2.1-8. All areas will have similar recontouring of slopes, seedbed preparation, fertilizer application, and planting schedule.

It will not be possible to replicate the replacement of the surface material due to limited available area along the stream channel and concern regarding additional sedimentation to Glen Creek. Therefore, the tests are designed as a split plot with three replications of the willow cuttings treatment. This design may be more correctly analyzed statistically as paired-plots with standard t-tests.

Test Area B

Two variables tested at Area B will be fertilizer application and willow cuttings. The fertilizer treatments are:

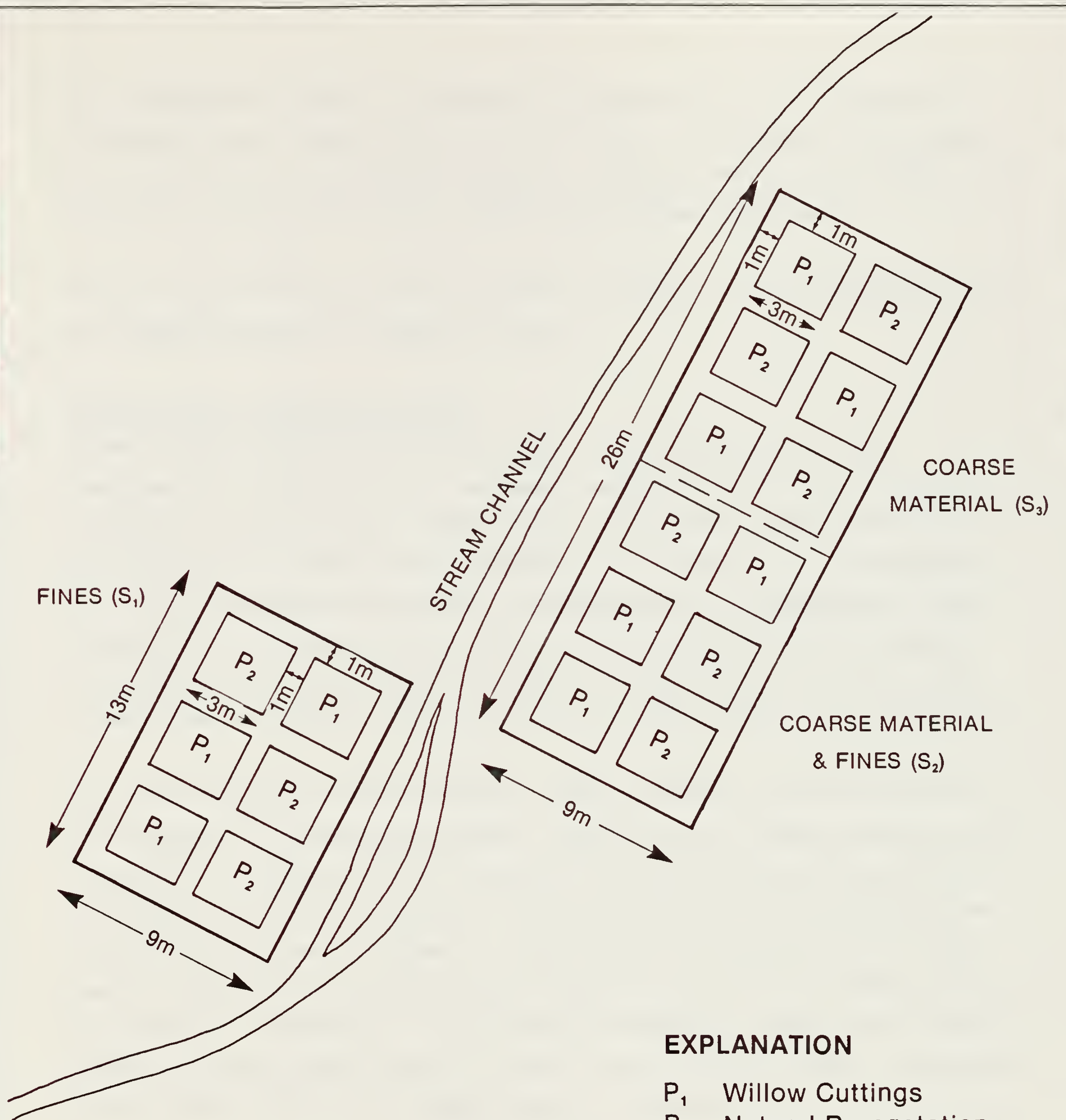
F_1 = No fertilizer;

F_2 = Fertilizer application (300 lb/acre)

The willow cuttings treatments are:

P_1 = Willow cuttings; and

P_2 = No willow cuttings (control).



EXPLANATION

P_1 Willow Cuttings

P_2 Natural Revegetation (control)

Figure 2.1-8
EXPERIMENTAL RECLAMATION PLOT DESIGN FOR TEST AREA A ON GLEN CREEK, DENALI NATIONAL PARK, ALASKA

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The experimental design is presented in Figure 2.1-9. This design is a randomized block design with three replicates. Treatments within each replication will be randomly selected. Standard analysis of variance can be done to statistically test differences between treatments.

Prior to application of the treatments, the area will be recontoured and the seedbed prepared as described above.

Woody Species Transplant Trials

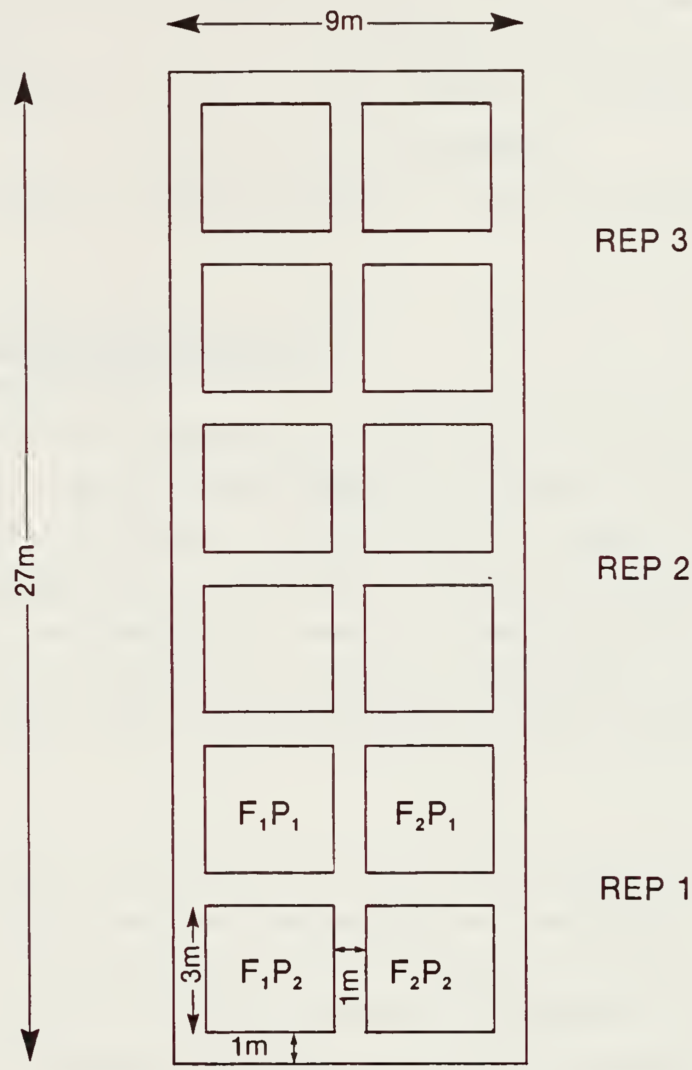
Woody species transplant trials will be established in the area designated in Figure 2.1-3. The woody species to be tested, transplant techniques, and spacing of individuals is described above. The size of the area to be planted with transplants will depend on the availability of suitable transplant materials as determined by the Reclamation Field Supervisor. It is important that a sufficient number of each species (recommend a minimum of 10 individuals) be transplanted so that valid comparisons in survival and vigor (height) can be made (see Section 3.1).

The area adjacent to the transplant trials should be fertilized (100 to 200 lb/acre) to investigate whether fertilizer will enhance natural seed production. Seed production in Alaska varies greatly in any given year. It appears that an average year of seed production is needed before any effect of fertilizer is apparent. Therefore, the results of the trial may be limited by the weather conditions of the next full growing season, and should be considered in evaluating the results. Sample plots (n=10) would be selected each from the natural area where fertilizer was applied and a similar area up- or downstream for comparison.

2.1.6 RECLAMATION SCHEDULE

Weather conditions may constrain the reclamation schedule since it is imperative that planting be conducted as early in the spring as possible to maximize moisture conditions for vegetative establishment. Therefore, Glen Creek reclamation activities are scheduled during two seasons.

Spring (May-July), Year 1
- Equipment/debris salvage
- Recontouring
- Stream channel restoration



EXPLANATION

F_1 No Fertilizer

F_2 Fertilizer

P_1 Willow Cuttings

P_2 Natural Revegetation (control)

Figure 2.1-9
EXPERIMENTAL RECLAMATION PLOT DESIGN FOR TEST AREA B ON GLEN CREEK, DENALI NATIONAL PARK, ALASKA

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Summer (August), Year 1	o	Topsoil placement
	o	Seedbed preparation
Spring (March-April), Year 2	o	Collection of willow cuttings
(April)	o	Seedbed preparation, if required
(April-May)	o	Planting of cuttings and transplants

Planting may require an additional year if sufficient labor is not available.

2.2 RADOVAN GULCH/NELSON PROSPECT

2.2.1 SITE DESCRIPTION

This site consists of a combination of two lode mine sites, Radovan and Nelson Prospects, and associated facilities located near Glacier Creek in Wrangell-Saint Elias National Park and Preserve (Figure 2.2-1). Most of the park and preserve area is extremely mountainous and includes some of the highest and most spectacular mountain country in North America. The Wrangell's region is noted for its geologic diversity. The region including both mine sites is characterized by narrow valleys with steep slopes.

The Nelson Prospect site consists of six claims encompassing 93.1 acres and an associated access road leading upslope from Glacier Creek. The Radovan Prospect workings are within the Augusta and Boots claim group and include a pad 50 x 100 feet, associated downslope tailings, and access road from Glacier Creek. Both sites have abandoned buildings, mining structures, open adits, tailings, scattered surface debris, and access roads which proceed upslope from Glacier Creek (Figure 2.2-2). Hazardous materials (e.g., old dynamite, chemical drums) are present on the sites.

The sites are located at elevations ranging from 2,200 to 4,000 ft msl on the north and northeast facing slopes above Glacier Creek less than three miles above its confluence with the Chitistone River. Several hundred active and abandoned lode mine sites are located in the general area. The two selected sites are representative of the problems encountered in reclaiming lode mine sites at many locations in Alaska national parks.

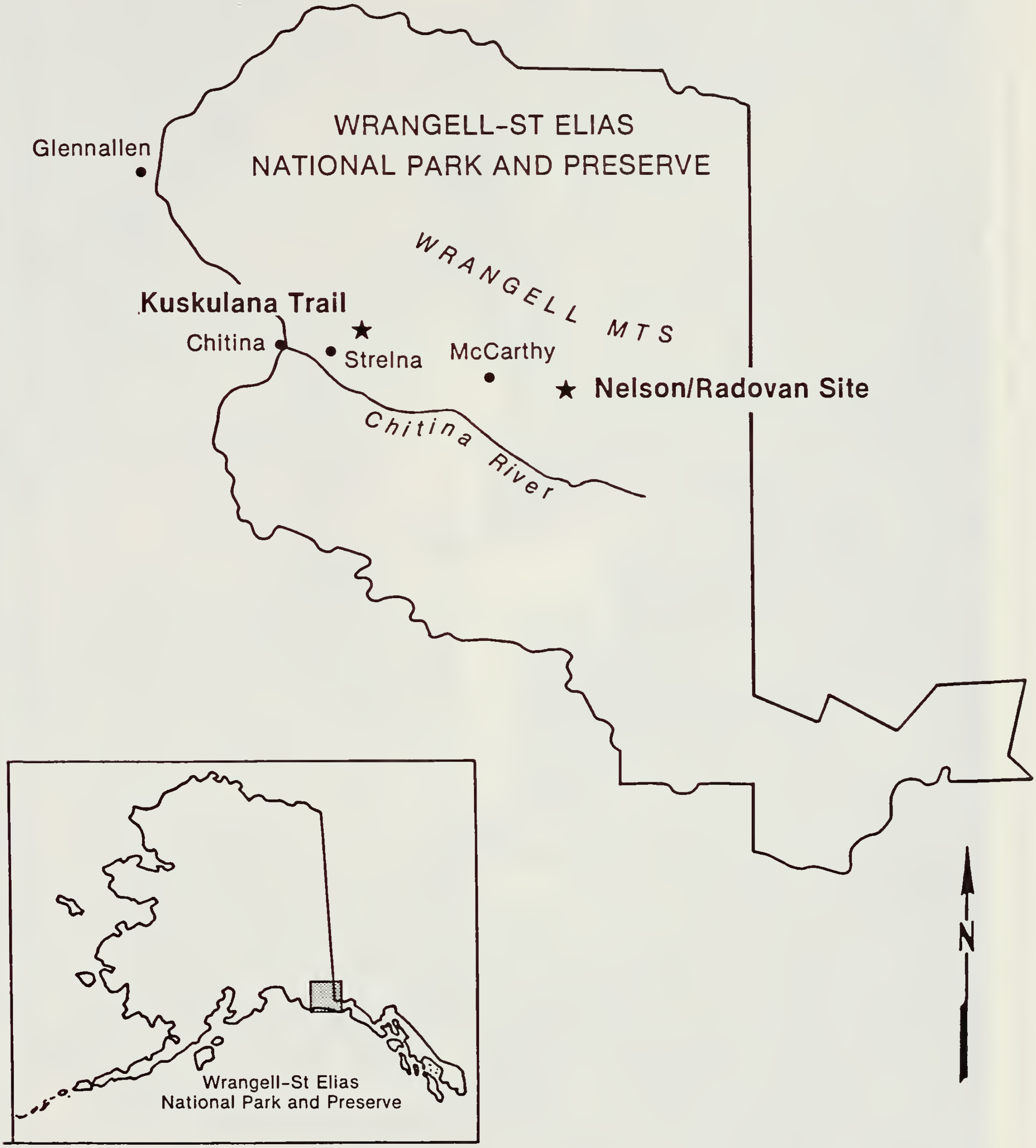

Figure 2.2-1
LOCATION OF NELSON/RADOVAN AND
KUSKULANA TRAIL SITES

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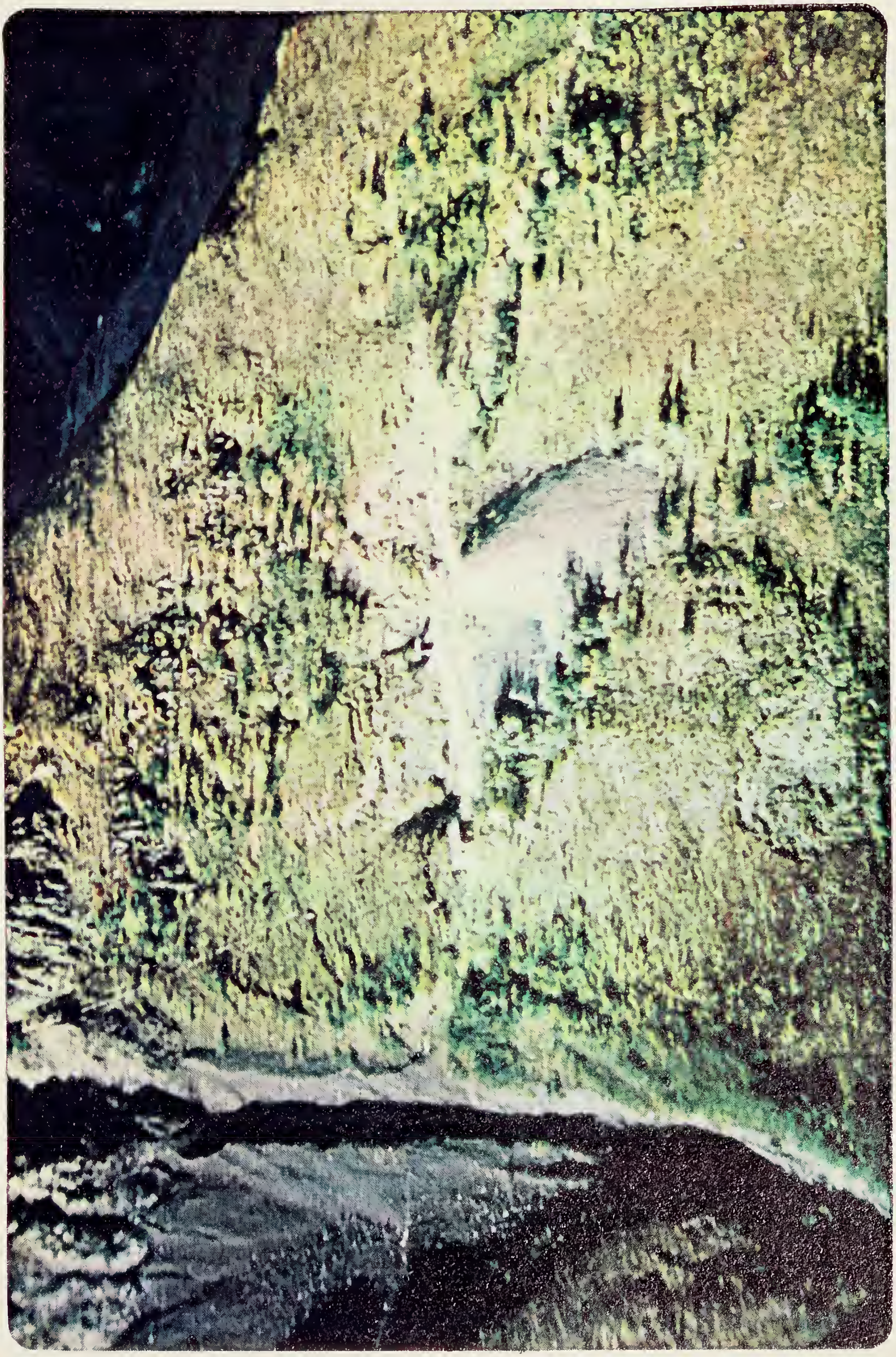


Figure 2.2-2 RADOVAN GULCH SITE

Bedrock in the area of both sites is highly mineralized Chitistone limestone in contact with the underlying Nikolai Greenstone. Brown loamy soil with abundant limestone fragments covers the northeast facing slopes where both mines are located. The upper slopes are primarily rocky talus with little soil.

The Nelson Prospect/Radovan Gulch sites occur in the Pergelic Cryumbrepts, very gravelly hilly to steep mountainous land association (SCS, 1979). These soils are common in mountainous areas throughout Alaska. One soil sample collected from the slope opposite the Nelson/Radovan area indicated that solids in the area are sandy loams with neutral pH (7.0), low conductivity, low organic matter (1 to 2 percent), and low nutrient levels. The soil sample results did not indicate toxic levels for heavy metals, although tailings and/or waste rock on the two sites could contain high levels of heavy metals (copper, arsenic, boron, etc.). Soil analysis results are presented in Table 2.1-1.

The gravel floodplain along Glacer Creek was covered by a dense mat of mountain avens (*Dryas drummondi*). Balsam poplar, willows, alder, and buffaloberry (*Shepherdia canadensis*) were scattered throughout. The well-drained, steep mountain slopes along Glacier Creek were vegetated by spruce-hardwood forest. White spruce, Alaska paper birch (*Betula papyrifera* subsp *humilis*), willows (*S. scouleriana*, *S. alexansis*), and American green alder (*Alnus crispa*) were common species. The Nelson Prospect site occurred in this forest vegetation. The access road which extended from Glacier Creek to the Nelson site had revegetated with hardwood species (willows, alder, balsam poplar). Tailings and/or waste rock on the site were sparsely vegetated which may indicate toxic properties of the substrate.

The Radovan Gulch site is located in more sparse vegetation in the transition between the spruce-hardwood forest and alpine vegetation. The access road from Glacier Creek traverses steep talus slopes which supported little or no vegetation. It appeared that no vegetation had invaded on this lower portion of the access road. On the Radovan site

and upper portion of the access road, scattered willows, balsam poplar, and white spruce occurred. Natural revegetation on the Radovan Gulch site was primarily grasses and forbs but overall revegetation was less than that which was observed on the Nelson Prospect site.

The Radovan Prospect and access road from Glacier Creek are mostly in sparse alpine tundra vegetation. The lower slopes are on loose rocky talus which supports open stands of white spruce, balsam poplar, and alder. The lower section of the access road traverses steep slopes and supports little vegetation. The buildings, level pad, and downslope tailings pile occupy an area of approximately 50 x 150 feet, several hundred feet above Glacier Creek. Surrounding vegetation is mostly sparse alpine tundra with scattered balsam poplar, white spruce, and alder trees. The pad area and upper portion of the access road are becoming revegetated with deciduous trees, primarily alders, which attain a height of several feet and are clearly visible from the valley floor.

A variety of wildlife species inhabit this region. Tundra and adjacent forest areas support larger species such as grizzly bear, Dall sheep, and mountain goat. Porcupine, arctic ground squirrel, pika, and snowshoe hare also occur in the area (Rearden, 1981). A variety of birds including Ptarmigan, raptors, and songbirds inhabit the area. Streams do not occur on these sites, although the water quality and fish habitat in Glacier Creek and the Chitistone River could be adversely impacted by lode mining.

2.2.2 RECLAMATION CONCERNS

Recent surveys conducted by the NPS on the abandoned Radovan and Nelson Prospects indicate that toxic and/or hazardous materials including unexploded dynamite, drums, and containers of solvents are present on the sites. Similar problems exist on other lode mine sites and must be considered in the development of mine site reclamation plans. It is assumed that these materials will be removed prior to the implementation of site reclamation.

Abandoned equipment, buildings, and other mine-related debris are obvious concerns. These items must be removed from the site prior to initiation of other reclamation activities. Tunnels, adits, and shafts are typical features of lode mines which are closed as part of site reclamation. Closure may consist of simply sealing the entrance or it may involve filling the openings. Removal of equipment and debris may be thus coordinated with mine closure, and may be used in mine closure.

Lode mine operations frequently occur on moderate to steep slopes. Mine development and related access roads can cause slope instability. Steep slopes in the Nelson/Radovan areas are a concern because of their visual impact and potential impact on slope stability. Construction of access roads can affect runoff, concentrating flows in some areas and increasing gulleying. Road and facility construction and actual mining usually create piles of surface debris which have steeper surface angles than natural slopes. Aside from the loss of vegetation beneath these piles, these unconsolidated materials are less stable and continue to move downslope, increasing the area of impact and preventing revegetation at the moving surface. Adit, shaft, and tunnel construction can also lead to slope instability due to mine subsidence. Access roads and mine operations which cut the slope, result in slumping of upslope materials in areas where structures have not been placed to prevent downslope soil/talus movement. Many of these features are present on the Radovan and Nelson Prospects.

Adits, shafts, and tunnels can cause additional reclamation problems. The removal of subsurface tailings and associated mine drainage can bring toxic substances to the surface where they prevent revegetation and contaminate surrounding areas. These impacts are most serious when mine drainage affects surface waters which are habitat for important fish species.

Tailings (the waste material remaining after chemical processing of ore material) is often toxic because of high concentrations of heavy metals (e.g., B, Pb, Cu, Zn, Al, or Mn) or its acidic properties (concentration of finely ground sulphide particles, commonly pyrite and

pyrrhotite). The specific chemical properties of the tailings on the Radovan and Nelson Prospect sites were not determined because access to these areas during the reconnaissance visit did not permit sample collection. Other sources of information regarding the chemical properties of the tailings at these sites does not exist to our knowledge.

Reclamation of tailings areas can be done in several ways:

- Remove the tailings materials and dispose of with a backfill manner into underground mine workings where the ore and overburden was removed;
- Bury tailings material by covering them with at least 30 cm of preferably surface material; and
- Revegetate the area directly using plant species tolerant of heavy metals.

In this study, as much of the tailings as possible will be placed in the adit and tunnels prior to closure. Nelson and Radovan are abandoned mine sites and suitable cover material does not appear to be available without causing additional surface disturbance. Therefore, the third option (above) is proposed since the Plant Material Center in currently investigating two plant species, Siberian wild rye (*Elymus Sibiricus*) and sagebrush (*Artemisia tilesii*). For operating mines, the use of surface soil or soil substitute to cover the tailing to a depth of at least 30 cm would be highly recomnmended. While this soil layer dilutes the concentration of heavy metals, it should be noted that upward migration of heavy metals could affect long term revegetation success. Therefore, it might be necessary to investigate or include a barrier layer (e.g., coarse rock) between the tailings and the surface soils to inhibit upward migration of the heavy metals by interrupting the capillary movement.

The visual impact of mining can be longterm and substantial. Tailings piles and mine openings remain visible for centuries in areas where revegetation is difficult due to severe environmental conditions and steep terrain. Tailings piles do not conform to surrounding surface features, and remain bare for long periods. Mine openings are frequently

visible from valley floors or adjacent slopes. Access roads are also visible because of the cut and fill approach used in their construction which affects the slope and intercepts runoff, creating gulleys and ditches which may hold water and favor the establishment of vegetation different from that present in the immediate area. These visual impacts are evident to some extent on both the Radovan and Nelson Prospect sites.

The re-establishment of native vegetation on both areas is important. These plant communities provide wildlife habitat, enhance slope stability, mask visual impacts, and provide vegetative cover consistent with surrounding areas. Lode mining creates a variety of conditions which affect successful revegetation. Slope instability, lack of soil on mine tailings, and presence of toxic materials in tailings result in conditions which retard or prevent the natural revegetation of mine sites on steep mountainside locations. Access road construction can create pockets of moisture and soil which promote rapid reestablishment of some vegetation, but this may not be visually consistent with the surrounding area. All of these factors must be considered in reclamation planning at lode mine sites in Alaska.

2.2.3 RECLAMATION PLAN

The objectives of the proposed reclamation plan for the Nelson Prospect/Radovan Gulch site include:

- o Mine closure and final reclamation of sites occurring on steep slopes where erosion control is important, and
- o Revegetation of mine tailings which may contain high concentrations of heavy metals.

Maintenance or management activities are not included in the reclamation plan as they are not needed. Similar reclamation plans will be implemented at the Nelson and Radovan sites unless specifically noted below.

2.2.3.1 Structure and Equipment Removal

It is assumed that there are no archaeological, historical, or geological values at the mine sites and therefore permanent closure and reclamation

is appropriate. Removal of hazardous materials will be complete prior to any reclamation activities. These materials will be identified, repacked, handled, stored, and transported in accordance with state and Federal regulations. Waste removal will involve chemicals, containers, and any contaminated soils on and near these sites. Because of the special requirements of this removal, it is beyond the scope of this reclamation plan.

All old equipment, debris, and torn-down buildings will be placed inside the mine adits. After all items have been placed in the adits, the adits will be permanently closed. Adits can be closed either by dynamite blasting or placement of a cement plug. Blasting is recommended due to the inaccessibility of the site and the cost effectiveness of this technique.

2.2.3.2 Site Preparation

If sufficient space is available in the adits at Radovan Gulch, tailings will be moved into the adits prior to closure to reduce the amount and slope of tailings present on the surface. Soil samples will be collected during site preparation to determine if toxic materials such as heavy metals are present in tailings which could inhibit natural revegetation. Except for the top of the tailings piles, no recontouring will be required at these sites. Disturbed areas devoid of vegetation will be tilled or ripped to a depth of six to twelve inches. The areas will be left in a roughened condition to enhance moisture infiltration, reduce erosion, and promote natural revegetation. Areas which have naturally revegetated will not be disturbed. Soil movements will be accomplished using a small bulldozer transported to the site by helicopter to avoid disturbing revegetated areas along the access roads to both sites.

The outer (downslope) edge of the access roads to both sites will be bladed or broken down to reestablish natural contours and to discourage future access to the sites. This will eventually improve visual conditions since the access roads will be less obvious when natural

contours and native vegetation become reestablished. Portions of the access roads which are to be revegetated will require ripping since they are compacted and rutted. The access road traversing the talus slope below Radovan Gulch will not be revegetated. Portions of the road are revegetating naturally, but much of the road is on steep barren slopes where establishment of vegetation would be difficult and inappropriate. It will be bladed to reestablish natural contours, prevent vehicular access, and reduce visual impact.

2.2.3.3 Plant Materials

The primary objective is to establish vegetative cover which will enhance erosion control and reduce visual impact on steep slopes. Thus, the following species mix will be used on disturbed areas except the tailings area:

Species	Rate (PLS) (lb/acre)
Bluejoint reedgrass var. sourdough (*Calamagrostris canadensis*)	4
Alsike clover var. Aurora (*Trifolium hybridum*)	1
Total	5

If bluejoint reedgrass is not commercially available, smooth brown variety Polar or Manchar can be substituted but the rate should be doubled. The above rates are drilling rates. If a drill is not used seed can be broadcast at double the drill rate. Care should be taken to ensure that broadcast seed is covered with soil material by raking or borrowing. Broadcast seed that is not covered with soil has shown poor germination.

The tailings on the sites indicate poor vegetative establishment. Although some tailings will be placed in the adits prior to closure, some tailings will remain on the surface. These tailings likely contain higher concentrations of heavy metals and are less stable than undisturbed surrounding soils. The Plant Materials Center at Palmer is currently testing several species which have shown high value in mine reclamation due to their tolerance of heavy metals (Moore 1986). These

species include a new variety of Siberian wild rye (Elymus sibiricus) and sagebrush (Artemisia tilesii). These species are not currently available. The NPS should pursue a cooperative effort with the Plant Materials Center to obtain these materials for testing at the Nelson Prospect/Radovan Gulch site.

2.2.3.4 Fertilizer

Chemical fertilizer (8-32-16) will be broadcast on the disturbed area at a rate of 300 lb per acre. Application will be made immediately after planting.

2.2.4 EXPERIMENTAL DESIGN

Experimental studies at the Nelson Prospect and Radovan Gulch sites will consist of a test of grass/forb seed mix and fertilizer treatments and species trials on the tailings. Areas not used for these studies will be recontoured, seedbed prepared, seeded, and fertilized as described above.

2.2.4.1 Experimental Study

Two variables will be tested at both sites. Seeding (grass/forb mix) treatments include:

P_1 = Grass/forb mix; and

P_2 = No seeding.

Fertilizer treatments are:

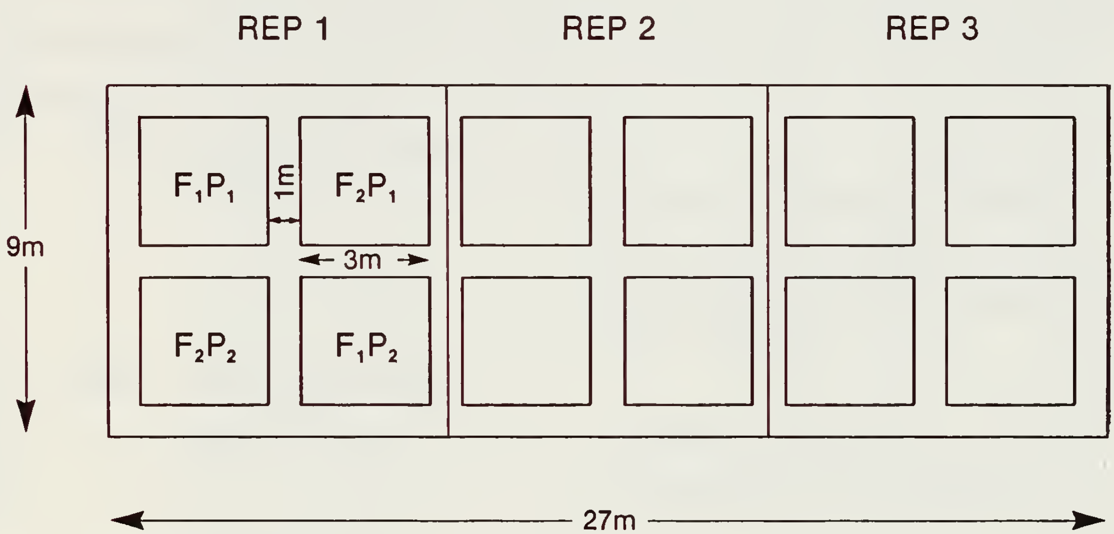
F_1 = Fertilizer (300 lb/acre); and

F_2 = No fertilizer.

The experimental design for these tests is presented in Figure 2.2-3. This is a randomized block design with three replicates. The results will be anlayzed by an analysis of variance. Recontouring and seedbed preparation techniques will be similar for all treatment plots.

2.2.4.2 Special Trials on Tailings

Some tailings are expected to remain on the surface after tailings are disposed of into the adit. As discussed above, the Plant Materials Center in Palmer is currently evaluating sagebrush (Artemisia talesii) and Siberian wildrye (Elymus sibiricus) since they appear to be valuable in reclaiming mine spoils because they are tolerant to heavy metals.



EXPLANATION

F_1 Fertilizer

F_2 No Fertilizer

P_1 Grass/Legume Seed Mix

P_2 Natural Revegetation (control)

Figure 2.2-3
EXPERIMENTAL RECLAMATION PLOT DESIGN FOR THE NELSON PROSPECT AND RADOVAN GULCH SITES, WRANGELL-ST ELIAS NATIONAL PARK, ALASKA

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These trials assume seed is available from the Plant Materials Center. Seeding will be done manually as recommended by the Plant Materials Center. These trials are qualitative and the results are not suitable for statistical analyses.

2.2.5 RECLAMATION SCHEDULE

Weather conditions will cause constraints on the reclamation schedule. Scheduling should be planned to allow planting to be done as early in the spring as possible and should not be done later than June 1. A fall planting (late August - early September) may be desirable if it can be scheduled prior to the first snowfall. The schedule for the Nelson/Radovan site is as follows:

Summer (June-Early August, Year 1)	o Removal of Hazardous waste (not part of plan) o Equipment and debris clean up o Adit Closure
Fall (Late August-Early September, Year 1)	o Seedbed preparation o Seeding and fertilizing

Fall activities could be delayed until Spring Year 2, if necessary.

2.3 KUSKULANA TRAIL

2.3.1 SITE DESCRIPTION

This site includes a section of the Kuskulana Trail northwest of Strelna in the Chitina River Valley near the confluence of the Kuskulana and Chitina Rivers in Wrangell-Saint Elias National Park and Preserve (Figure 2.2-1). Site elevations range from 1,600 to 1,800 feet above mean sea level. The site is approximately 1.5 miles east of Nugget Creek Junction on the Kotsina Road and includes a section of trail approximately one mile long in Section 7, Township 4 South, Range 8 East (Figure 2.3-1). This trail section traverses a north-facing slope which is underlain with permafrost. Trail sections east and west of this section are on flat or generally south-facing slopes and are not affected

Figure 2.3-1 KUSKULANA TRAIL SITE LOOKING EAST

by permafrost. Repeated trail use by motor vehicles, horses, and foot travelers has destroyed much of the vegetation and causes problems which are typical of surface disturbance in discontinuous permafrost areas throughout the arctic.

The deterioration of the main trail has resulted in the construction of alternative routes through surrounding vegetation in order to circumvent flooded and muddy sections of the road. These routes have caused the flattening of trees up to four inches DBH, compression of the thick layer of tundra vegetation, and sections where the corduroy method of trail construction have been used (Figure 2.3-1). These in turn have deteriorated and forced use of additional trails. This trail will continue to deteriorate unless substantial labor and money are invested in its restoration and/or reclamation, and without the cessation of the current types and levels of use.

This site occurs within the transitional zone of climatic influences and receives precipitation intermediate between the moist coastal area and comparatively dry interior. Annual temperature fluctuations of more than 150 degrees F occur in the region. Temperature extremes range from minus 65 to over 90 degrees F. Precipitation amounts are variable because of the transitional location of the area, but are generally around 80 inches annually and with a seasonal snowfall consistently more than 600 inches. Permafrost areas are present on protected north-facing slopes even at low elevations.

Soils on this trail section are coarse loamy, mixed histic, pergelic cryaquepts (SCS, 1979) with a shallow permafrost table on north-facing slopes. On undisturbed sites the soil is characterized by the presence of shallow, permanently frozen mineral soil (10 to 16 in from the surface) and a thick peaty surface material over dark gray, very gravelly and stony silt loam or sandy loam. Textures of the surface mineral horizon were predominantly a mucky silt loam 10 to 20 in thick underlain by gravelly silt loams and sandy loams (Morrison, 1984). Soil drainage is consistently poor. Site relief is gently sloping (7 to 10 percent) and concave. Several minor drainageways dissect the slope. Soil

samples collected along the trail had loam texture, were acidic (pH 5.6 to 6.2), and had a higher organic matter content (3 to 6 percent) compared to the other sites (Table 2.1-1).

Soil sampling surveys conducted by Morrison (1984) revealed that the permafrost depth had dropped to 24 inches on recently used trail sections adjacent to the main trail, and that frost depth was greater than 40 inches on abandoned trail routes with water-filled ruts. The already poor downslope drainage was further impaired by the lowering of the permafrost along the trail, ponding and diversion of the water in trail ruts, and the concentration of runoff in vehicle tracks (Figure 2.3-1). Soil samples collected along the trail had loam texture, were acidic (pH 5.6 to 6.2), and had higher organic matter (3 to 6 percent) as compared to the other sites.

Vegetation along the trail was typical of poorly-drained soils in the spruce-hardwood forest type. White spruce was replaced by black spruce (*Picea mariana*) and the trees are scattered with an open canopy. The understory consisted of shrub species of bog blueberry (*Vaccinium uliginosium*), mountain cranberry (*V. vitis-idaea*), Laborador tea (*Ledum* sp.) and a thick, dense mat of mosses. Invader species were observed along the disturbed trail. Several willow species (*S. arbusculoides, S. flauca, S. commutata*) were common along with scattered aspens (*Populus tremuloides*). Fireweed, cinquefoil (*Potentilla* sp.), and wild strawberry (*Fragaria* sp.) were scattered throughout. In areas where standing water occurred, sedges (*Carex bonanzensis*) and rushes (*Juncus castaneous*) was found. Grasses (*Agrostis scabra* and *Calamagrostis canadensis*) were uncommon.

Black bear, grizzly bear, and moose are the largest inhabitants of the area. The saturated soil conditions prevent burrowing species such as the arctic ground squirrel from living here. Snowshoe hare, vole species, and fox also occur in the region. A few birds including songbirds and raptors inhabit the area.

2.3.2 RECLAMATION CONCERNS

The overriding reclamation/restoration concern for this site is permafrost. Frozen ground poses few engineering or environmental problems if it is not disturbed. Once permafrost conditions are disturbed, however, a series of complex processes are set in motion which are not easily controlled or reversed.

The consequences of disturbing the insulating vegetation layer which overlies permafrost areas include thawing of the underlying permafrost which causes subsidence and solifluction, the gravity-controlled movement of water-saturated surficial sediments. Removal or compression of vegetation disturbs the thermal balance causing a thawing of the upper permafrost layer. Once started, it may be difficult or impossible to control (Ray, 1983).

Related phenomena which occur as a result of thawing include soil creep, slumping and subsidence, icings, and severe frost heaving. The downslope movement of water beneath the dense layer of vegetation may increase as a result of differential disturbance of the surface insulating layer and consequent subsurface melting. The vegetation mat may rupture, and a slurry of water-saturated sediments will flow onto the surface vegetation, creating additional surface disturbance. All of these effects have been observed within the study site along the Kuskulana trail.

The downslope movement of water is impeded by the trail which cuts across the slope, diverting the water into ponded areas along the road or deflecting it into surface channels along ruts which cut deep channels through the organic layer to the level of the underlying substrate. Areas downslope from the road may become dry as water is diverted along the road, and downslope vegetative cover may be affected. The differential distribution of surface water creates pockets of vegetation including sedges and willows which concentrate in the flooded exposed surface areas.

2.3.3 RECLAMATION ALTERNATIVES

Reclamation potential of the Kuskulana Trail is limited because of the progressing degradation of the permafrost. This disturbance to the trail by vehicular use has caused disturbance to the surface organic layer and vegetation which insulated the soil. With the removal of the layer, water collects in the ruts and tracks and acts as a heat sink which further depresses the level of the permafrost. Thus, the damage to permafrost initiates a process which is irreversible unless substantial efforts are made to insulate the underlying permafrost.

Because of the resources necessary to permanently reclaim damaged permafrost areas and the conflict with existing land uses, three options are described regarding the Kuskulana Trail.

Option 1-Continued Recreational Use

This road is presently used for recreational purposes which has caused irreversible damage to the permafrost. The first option is to continue use, monitor the trail, and determine the permafrost level (see Section 3.3).

Option 2-Eliminate Vehicular Use, Create Water Diversions and Revegetate

Damage along the Kuskulana Trail will continue unless all use of the area is discontinued. The road should be blocked from both sides and the area should be posted to restrict further use, particularly from use above and below the current trail.

The trail will be regraded to eliminate the ruts and tracks which collect water and act as heat sinks causing more frost melt. Water diversions should be constructed at two or three locations midway along the trail to divert water away from the trail so that rutting or ponding along the newly bladed trail does not occur.

The area will be seeded with grasses (*Calamagrostis canadensis* and *Beckmannia erucaeformis*, if available) (Moore 1986) at a rate of 5 lb (PLS) per acre. Grasses would provide the vegetative cover necessary to initiate reestablishment of the insulation layer. Revegetation will not re-establish the natural permafrost conditions but it should minimize any additional damage to the area.

Option 3-Reconstruction of Kuskulana Trail

To continue vehicular use of the trail and minimize additional damage to surrounding habitat, extensive reconstruction of the trail is necessary. Reconstruction would include excavating the road a minimum of two to three ft, placement of gravel or other insulating materials, and construction of water diversions, to prevent further damage to the permafrost zones. As indicated by Morrison (1984), measures such as corduroying the trail with willows or spruce is temporary and does not correct the problems created by past use. Revegetation along the trail will also not correct the condition in the near-term (Option 2). Proper engineered reconstruction of the trail appears to be the only means to allow continued use of the trail. An alternative presented by Morrison (1984) was to relocate the trail to a south facing area across a permafrost free slope.

If access to Kuskulana Trail could be eliminated, then revegetating the trail (Option 2) and monitoring the long term conditions (Option 1) is recommended.

3.0 RECLAMATION MONITORING

3.1 LOWER GLEN CREEK SITE

3.1.1 REVEGETATION

Test Area A

Experiments at Test Area A are designed to investigate the effect of surface material (3 treatments) and revegetation (plantings) versus natural revegetation (2 treatments). These treatments are replicated three times for a total of 18 treatment plots (3 x 2 x 3 = 18).

As described in Section 2.1.3.3, 16 cuttings will be planted in treatment plots designated for plantings. Survival (percent) and vigor (height) of all woody plants, will be the parameters monitored to evaluate revegetation success. Mean survival (%) and mean height (cm) of the willow cuttings will be calculated for each treatment plot. Each parameter (survival height) will be tested as paired plot with standard t-test to determine if significant differences existed among treatments. All individual plants which invade the plots will also be monitored since these invaders will indicate the potential for natural revegetation.

Photoplots will be established at each of the 18 treatment plots. A permanent marker will be established so that photographs can be taken at the same location. Since planting is scheduled for early spring, photographs will be taken four weeks after planting (May) and at the end of the first growing season (August-September). Photographs will be taken annually beginning with the second growing season. Photographs are not suitable for quantitative analysis but will provide a visual record of revegetation success.

Measurements will be made at the end of the first growing season (August-September) and annually thereafter for a total of three years. Monitoring will be evaluated to determine if further monitoring is warranted.

Test Area B

Monitoring of Test Area B will be similar to that of Test Area A except that 12 treatment plots will be set up in this area.

Woody Species Transplant Trials

A minimum of ten individuals of each woody plant species will be transplanted. These ten individuals will be permanently marked to distinguish them from invader individuals. These individuals will be measured to determine survival (percent) and vigor (height) for each species. Mean survival (%) and height (cm) of the transplants should be calculated for each transplanted plant species. Mean values will be compared to evaluate success of the various species, but the data are not suitable for analysis of variance.

In areas where fertilizer has been applied to the natural vegetation, a sample plot (10 m x 10 m) will be established. A control area will be selected in similar vegetation in an unfertilized area. Seed production in each area will be examined to determine if the fertilizer application has increased seed production. This study is qualitative and not suitable for statistical analysis.

3.1.2 STREAM RESTORATION

In addition to reclaiming the entire stretch of Glen Creek within the site, a major objective of stream restoration techniques used on the lower Glen Creek site is to test experimental reclamation techniques. It is assumed that desirable stream restoration, the basis for evaluating restoration success, closely resembles conditions encountered under natural, unperturbed, unmodified stream ecosystems. It is also assumed that stream sections to be compared are similar based on physical and chemical characteristics, and that they have similar but not necessarily identical biotic communities.

Experimental reclamation plots encompassing segments of the restored stream channel established along the creek will be subjected to various treatments designed to enhance channel stability and biotic habitat. To assess the success of these treatments, control areas will be selected on similar, but undisturbed portions of Spruce Creek. Four samples will be collected from the lower stream segment within each of the three designated experimental reclamation areas (Figure 2.1-3). Four samples will also be collected from a sample site in an undisturbed segment of

the stream channel immediately above the reclaimed portion of Glen Creek. Two sample sites (four samples each) will be located on undisturbed segments of Spruce Creek to serve as controls. The location of these sites will be determined at the time of reclamation on lower Glen Creek.

Sites will be sampled during summer low flows and will be sampled prior to site reclamation, within the first summer following stream channel restoration, and yearly for the first five years following reclamation. Sampling will then be conducted at two year intervals for the next 10 years or until it is determined that successful reclamation has been achieved and that verifiable conclusions can be drawn on the success of the experimental reclamation procedures.

The monitoring of stream reclamation will be integrated with the monitoring of revegetation and erosion control on terrestrial portions of the experimental plots. The approach for evaluating stream restoration and comparing experimental plots will follow the intergrated physical, chemical, and biological methodology developed by Winget and Mangum (1979). This methodology involves the use of a biotic condition index (BCI) based on water quality, physical habitat, and aquatic biota data and is designed to be used in conjunction with water quality, physical habitat, and hydrological studies.

Four independent variables were selected for use in the BCI because: 1) there are strong relationships between these parameters and the dependent biotic parameters, and 2) each represented a different type of influence on the structure and function of the biotic community. The variables selected were: stream channel percent gradient (stream maintenance and recovery component), substrate roughness (microhabitat heterogeneity component), total alkalinity (density and biomass component), and sulfate/total dissolved solids concentrations (water quality component).

Percent gradient is used because of its positive correlation with macroinvertebrate density and its relationship to the ability of a stream to maintain substrate quality. Recovery from perturbations such as placer mining is quicker in streams with higher gradients and coarser

substrates such as Glen Creek. There is a high degree of correlation between macroinvertebrate community structure and substrate roughness (Winget 1985). The greatest number of species are found on substrates with boulders and rubble and with limited quantities of interstitial gravel, sand, and organic fines. Substrate roughness is calculated using the following formula:

$$\text{Substrate Roughness} = \frac{(5 \times C_1) + (3 \times C_2) + C_3}{9}$$

where

Subscript:

1 = most dominant substrate type

2 = second most dominant substrate type

3 = third most dominant substrate type

Coarseness Values:

			C
boulder	> 1 ft	=	4
rubble	3 - 12 in	=	3
gravel	1 - 3 in	=	2
fines	< 1 in	=	1

Total alkalinity was selected because of its relationship to community density and standing crop biomass. Alkalinity is important in primary production. Specific conductance shows a similar but weaker correlation.

Sulfate/total dissolved solids (TDS) is used because an increase in sulfate concentration generally indicates a decline in water quality and corresponding reduction in macroinvertebrate community diversity. Because many geologic formations contribute fine sediments and dissolved solids, total dissolved solids can and may be used in place of sulfate.

The use of tolerance quotients (Winget 1985) and other applications of the biotic condition index will be a function of onsite and control area conditions and will be determined at the time of reclamation. Control and experimental areas will be sampled at the same season to reduce

sample variability due to timing. Sampling of stream fauna will be accomplished using a Hess or modified Surber sampler. This device is recommended because the enlarged bag prevents the loss of sample materials due to backwash when sampling swift water areas and the fine mesh allows the collection of small instar larvae. These considerations are relevant to stream conditions and expected benthic macroinvertebrate populations in control and experimental areas.

3.2 RADOVAN GULCH/NELSON PROSPECT

Monitoring--The experiment is designed to investigate seeding (2 treatments) and fertilizer (2 treatments); the experiment is replicated three times. Total treatment plots equal 12 (2 x 2 x 3 = 12).

Species composition and vegetative cover (percent) will be evaluated at each treatment plot. Three sampling plots (1 x 1 m) will be measured at each treatment plot. Species composition and cover will be measured at the end of the growing season (August-September) for the first three growing seasons.

Results will be analyzed by an analysis of variance. Cover (%) measured in each of the three sampling subplots (1 x 1 m) within each treatment plot will be averaged to obtain a mean cover value for each species present and for total cover. Three replicate treatment plots (n = 3) have been established. The mean cover values (%) from the subplots must be calculated to determine a mean value for the treatment. The mean values for each treatment plot will be statistically compared by an analysis of variance to determine if significant differences occur among treatments.

Photoplots will be established and permanently marked at each treatment plot. Photographs will be taken when cover sampling is conducted.

Species Trials on Tailings

Revegetation success of sagebrush and Siberian wildrye will be determined by evaluating cover (percent). Cover will be ocularly estimated in five 1 x 1 m plots. These results are not suitable for further statistical

analyses. Mean cover will be calculated to determine a quantitative estimate of percent cover on the revegetated tailings area.

Photoplots (2) will be established and permanently marked to visually monitor the success of these two species in revegetating tailings.

3.3 KUSKULANA TRAIL

Reclamation potential of the Kuskulana Trail is limited because of the progressing degradation of the permafrost. The disturbance to the trail by vehicular use has caused disturbance to the surface organic layer and vegetation which insulates the soil. With the removal of the layer, water collects in the ruts and tracks and acts as a heat sink which further depresses the level of the permafrost. Thus, the damage to the permafrost initiates a process which is irreversible unless substantial efforts are made to insulate the underlying permafrost.

Because of the resources necessary to permanently reclaim damaged permafrost areas and the conflict with existing land uses, three options are described regarding the Kuskulana Trail.

Option 1-Continued Recreational Use

This road is presently used for recreational purposes which has caused irreversible damage to the permafrost. The first option is to continue use and to monitor the trail to deter the rate of progressive and irreversible deterioration which is taking place, and determine the permafrost level. Ponding of water in the ruts of this section of trail have forced users to take alternative routes which cause further damage both upslope and downslope from the existing trail. Morrison (1984) has noted the use of these alternative routes and the effectiveness of using the corduroy method for continuing trail use. He further suggests the use of water bars to alleviate the ponding problem, but this alternative may cause additional downslope deterioration.

To monitor the effects of trail damage on this slope, permanent transects have been established in areas of the trail where the trail is a single path and where multiple paths (the main trail and alternative routes) are

present (Figure 3.3-1). These areas could be monitored during spring, summer, and winter to document the effects of water on the disturbed areas and on the surrounding vegetation. Camera points should be established which cover these plots and at additional areas where effects such as slumping, ponding, frost-heaving, etc. have been observed. Color photographs should be taken at each season, and measurements made on the status of vegetation cover, species composition in each plot, and vegetation height. These measurements may be used to document subtle changes in vegetation cover brought about by flooding in some sections and drying in exposed downslope areas which appear to be well drained.

Surveys should be conducted once each year for the first 3 to 5 years, then intermittently thereafter, depending on the changes and rate of change noted during the first three years. These surveys would be relatively inexpensive, yet provide the NPS with an objective basis for evaluating continued impacts on this trail and on access roads in similar areas.

<u>Option 2-Eliminate Vehicular Use, Create Water Diversions and Revegetate</u>
A series of monitoring transects similar to those presented in Figure 3.3-1 will be installed following the trail closure and modifications described under Option 2 in Section 2.3-3. Each transect will include one plot within the road/trail portions which have been regraded and revegetated. Plot monitoring will be conducted according to the methods and schedule described under Option 1.

<u>Option 3-Reconstruction of Kuskulana Trail</u>
To continue vehicular use of the trail and minimize additional damage to surrounding habitat, extensive reconstruction of the trail is necessary. Reconstruction would include excavating the road a minimum of two to three feet, placement of gravel or other insulating material, and construction of water diversions, to prevent further damage to the permafrost zones. As indicated by Morrison (1984), measures such as corduroying the trail with willows or spruce is temporary and does not correct the problems created by past use. Revegetation alone will also not correct the condition in the near-term (Option 2). Proper engineered

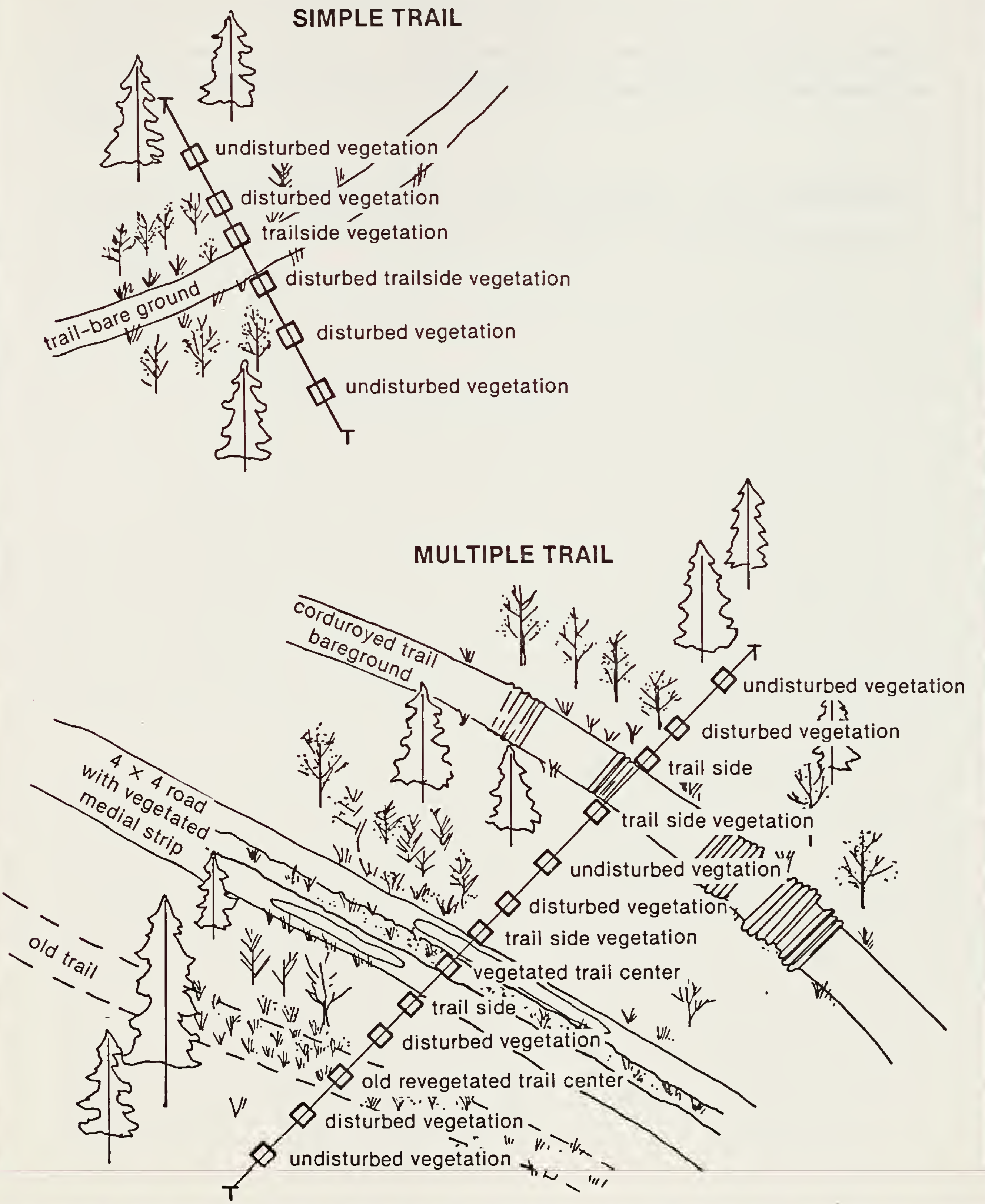

Figure 3.3-1
PERMANENT MONITORING TRANSECTS
ON THE KUSKULANA TRAIL
SOURCE: MORRISON, 1984

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reconstruction of the trail appears to be the only means to allow continued use of the trail. An alternative presented by Morrison (1984) was to relocate the trail to a south-facing area across a permafrost-free slope.

If access to the Kuskulana Trail could be eliminated, then revegetating the trail (Option 2) and monitoring the long-term conditions (Option 1) is recommended.

4.0 APPLICATIONS TO ALASKA NATIONAL PARKS

The NPS has responsibility for national parks and preserves throughout Alaska. National parks which have been or potentially may be disturbed by major mining activity include: Denali, Gates of the Arctic, Lake Clark, Wrangell-St. Elias, and Yukon Charley. These parks are focus for the following discussions.

The vegetation types that occur in the national parks of concern are listed in Table 4-1. Most mining in Alaskan parks occurs in five vegetation types:

- Spruce-hardwood forests;
- Open, low growing spruce forests;
- Moist tundra;
- Alpine tundra; and
- Shrub thickets.

Climatic conditons, precipitation, temperature, and soils in the forest and shrub vegetation types are less harsh than those existing in the tundra types (moist, alpine). Most of the forest and shrub vegetation types are dominated by tree and shrub species (Table 4-2).

Reclamation practices often rely on grasses and forb species, but successful use of grasses and forbs in Alaska is limited. Exotic plant species have not been successful because they require periodic maintenance (e.g., fertilizer) and have been found to inhibit invasion by native species (Kubanis, 1982). Native seed production is erratic and often not commercially available. Information on native species adaptable for reclamation use is limited to three native grass species: bluejoint reedgrass (*Calamagrostris canadensis*), polargrass (*Arctogrostis latifolia*), and bluegrass (*Poa glauca*). Research is being done at the Plant Materials Center in Palmer related to *Beckmannia erucaeformis*, Siberian wildrye (*Elymus sibiricus*), alpine bluegrass (*P. alpina*).

Forbs are presently limited to commercially available legumes (e.g., Alsike clover, red clover, white dutch clover, white and yellow

Table 4.1. Vegetation Types[1] in Alaska National Parks Where Mining Potentially Occurs

National Park	Vegetation Types
Denali National Park	Closed spruce-hardwood forests; Open; low growing spruce forests; Moist tundra; Alpine tundra
Gates of the Arctic National Park and Preserve	Closed spruce-hardwood forests; Shrub thickets; Moist tundra; Alpine tundra
Lake Clark National Park and Preserve	Closed spruce-hardwood forests; Shrub thickets; Moist tundra; Alpine tundra
Wrangell-St. Elias National Park	Closed spruce-hardwood forests; Open, low growing spruce forests; Shrub thickets; Moist trundra; Alpine tundra
Yukon Charley National Park and Preserve	Closed spruce-hardwood forests; Shrub thickets; Moist tundra; Alpine tundra

1 Vegetation types are described by Viereck & Little, Jr. (1972).

Table 4.2. Vegetation Types Occurring in Alaska National Parks, Locale, and Common Plant Species (Page 1 of 4)

Vegetation Type	Species Common to Vegetation Type	Vegetation Subtypes	Locale of Vegetation Subtype
Closed Spruce-Hardwood Forest	<u>Trees</u> White Spruce [1,2] Paper Birch [1,2] Balsam Poplar [1,2]	White Spruce	Warm, dry, south-facing hillsides, adjacent to rivers where drainage is good, permafrost lacking.
	<u>Shrubs</u> Red-fruit bearberry [1,2] Crowberry [1,2] Narrow-lead Labrador tea [1,2]	Quaking Aspen	Burn areas, upland south-facing slopes replaced by white spruce
	American red currant [1,2] Prickly rose [1,2] Feltleaf willow [1,2] Littletree willow [1,2] Buffaloberry [1,2]	Paper Birch	Invader after fires, east-and west facing slopes
	Mountain cranberry [1,2] Bog blueberry [1,2] Highbush cranberry [1,2] Barclay willow [1,2] Scouler willow [1,2] Dwarf blueberry [1,2] Bearberry [1,2] American green alder [1,2] Sitka alder [1] Thinleaf alder [1,2]	Balsam Poplar	Floodplains of meandering glacial rivers
Open, low growing spruce forests	<u>Trees</u> Black spruce [1,2] Tamarack [1,2] Paper Birch [1,2] White Spruce [1,2] <u>Shrub</u> Red-fruit bearberry [1,2] Crowberry [1,2] Labrador tea [1,2] Prickley rose [1,2] Littletree willow [1,2] Bebb willow [1,2] Grayleaf willow [1,2] Blueberry willow [1,2] Diamondleaf willow [1,2] Scouler willow [1] Bog blueberry [1,2] Mountain cranberry [1,2]		North-facing slopes and poorly drained lowlands. Leads to open black spruce and bogs, usually underlain by permafrost.

Table 4.2. Vegetation Types Occurring in Alaska National Parks, Locale, and Common Plant Species (Continued, Page 2 of 4)

Vegetation Type	Species Common to Vegetation Type	Vegetation Subtypes	Locale of Vegetation Subtype
Shrub Thickets[3]	Stika alder [1] American green alder [1,2] Thinleaf alder [1,2] Red-osier dogwood [1,2] Silverberry [1,2] Sweetgale [1,2] Prickly Rose [1,2] American red raspberry [1,2]	Floodplain thickets	River flood-plains on newly developed alluvial deposits that are periodically flooded
	Feltleaf willow [1,2] Littletree willow [1,2] Barclay willow [1,2] Bebb willow [1,2] Barren-ground willow Undergreen willow Grayleaf willow [1,2] Halberd willow Sandbar willow Richardson willow [1,2] Pacific willow Park willow Tall blueberry willow Diamondleaf willow [1,2] Setchell willow Sitka willow [1] Buffaloberry [1,2] Highbush cranberry [1,2] Alpine bearberry [1,2] Resin birch Dwarf artic birch [1,2] Beauverd spirea [1,2] Mountain cranberry [1,2] Bog blueberry [1,2] Narrow-leaf Labrador tea [1,2] Bush cinquefoil [1,2] Alaska bog willow [1,2] Netleaf willow [1,2]	Birch-alder-willow thickets	Near tree line in interior Alaska, beyond treeline in Alaska and Seward pensinulas
Moist Tundra	Cottongrass American green alder [4] Alpine bearberry [4] Resin birch Dwarf artic birch [4] Four-angled cassiope Entire-leaf mountain-avens White mountain-avens Narrow leaf Labrador-tea [4]		Foothills and lower elevations of Alaska range and on Seward and Alaska peninsulas, and island of Bering Sea

Table 4.2. Vegetation Types Occurring in Alaska National Parks, Locale, and Common Plant Species (Continued, Page 3 of 4)

Vegetation Type	Species Common to Vegetation Type	Vegetation Subtypes	Locale of Vegetation Subtype
Moist Tundra (Continued)	Alpine-azalea		
	Lapland rosebary [4]		
	Arctic willow		
	Barclay willow		
	Barratt willow		
	Chamisso willow		
	Undergreen willow		
	Alaska bog willow [4]		
	Grayleaf willow [4]		
	Richardson willow [4]		
	Diamondleaf willow [4]		
	Ovalleaf willow		
	Polar willow [4]		
	Netlef willow [4]		
	Least willow		
	Beauverd specia [4]		
	Bog cranberry		
	Bog cranberry [4]		
	Mountain cranberry [4]		
Alpine Tundra	Moss campion		All mountain ranges in Alaska, exposed ridges in arctic and southwest coastal areas
	Black oxytrope		
	Arctic sandwort		
	Alpine bearberry [4]		
	Resin birch		
	Dwarf arctic birch [4]		
	Alaska cassiope		
	Mertens cassiope		
	Starry cassiope		
	Four-angled cassiope		
	Diapensia		
	White mountain-avens		
	Entire-leaf mountain avens		
	Crowberry [4]		
	Alpine-azalea		
	Narrow-leaf Labrador-tea[4]		
	Luetkea		
	Aleutian mountain-heath		
	Blue mountain-heath		

Table 4.2. Vegetation Types Occurring in Alaska National Parks, Locale, and Common Plant Species (Continued, Page 4 of 4)

Vegetation Type	Species Common to Vegetation Type	Vegetation Subtypes	Locale of Vegetation Subtype
Alpine Tundra (Continued)	Red mountain-heath		
	Kamchatka rhododendron		
	Lapland rosebay [4]		
	Arctic willow		
	Chamisso willow		
	Alaska bog willow [4]		
	Ovalleaf willow		
	Skeletonleaf willow		
	Polar willow [4]		
	Diamondleaf willow [4]		
	Netleaf willow [4]		
	Least willow		
	Dwarf blueberry		
	Bog blueberry [4]		
	Mountain cranberry [4]		

1 Recommended woody plant species for the Cook Inlet - Susitna Area (Alaska Rural Development Council, 1983).

2 Recommended woody plant species for the Interior area (Alaska Rural Development Council, 1983).

3 Coastal alder thickets not included.

4 Recommended woody plant species for the arctic/alpine tundra (Alaska Rural Development Council, 1983).

sweetclover); their use should be limited to erosive areas. The Plant Materials Center is investigating reclamation potential of Hedysarum species and Oxytropis campestris (Moore, 1986). Although plant materials are available (Table 4-3), sources for quantities of native grass seed are limited (Table 4-4).

Reclamation plans for disturbed areas where re-establishment of native plant communities is important should include woody plant species in the revegetation plan. Many of the common tree and shrub species are suitable for reclamation (Table 4-2). Common and scientific names of native plant species are presented in Appendix B. Additional plant material sources are needed to provide sufficient materials. Therefore careful planning and scheduling is critical.

Reclamation potential of the five vegetation types has been ranked in regards to the harshness of the environmental conditions and the availability of suitable plant materials, particularly woody species (Table 4-2). The following ranking lists the vegetation types in decreasing order of reclamation potential:

- Spruce-hardwood forest;
- Shrub thickets;
- Open, low growing spruce forest;
- Moist tundra; and
- Alpine tundra.

The above discusses plant species recommended for use in the parks. The following are general guidelines for reclamation practices:

- Minimize the area (acreage) to be disturbed by planning operations prior to initiation of activities. Access to surrounding undisturbed areas should be limited.
- Disturbance to permafrost should be avoided, if possible. Where disturbance is unavoidable, insulation materials, such as gravel, should be used to avoid melting the underlying frost areas.

Table 4-3. Suppliers of Plant Materials

Alaska Greenhouse, Inc., Corner Muldoon & Debarr Road, 1301 Muldoon Road Anchorage, Alaska 99504, Phone (907) 333-6970

Alaska Mill Feed & Garden Center, 1501 E. 1st Ave., Anchorage, Alaska 99504, Phone (907) 276-6016

Alaska Tree & Garden Center, 1035 Blair Road, Fairbanks, Alaska 99701 Phone (907) 456-5173

Alberta Wheat Pool, Seed & Fertilizer Division, Box 2700, Calgary, Alberta T 2P 2P5, Phone 267-4910

Country Gardens Nursery, SRA Box 171, Anchorage, Alaska 99502, Phone (907) 344-2088

Fairview Nursery, SRB Box 5206, Wasilla, Alaska 99687, Phone (907) 376-5689

Jacklin Seed Company, West 5300 Jacklin Ave., Post Falls, Idaho 83854 Phone (208) 773-7581

LaSalle Nursery, 2035 LaSalle Road, Kalispell, MT 59901, Phone (406) 755-0900

Lawyer Nursery, Plains, MT 59859, Phone (406) 826-3229

Lee's Gardens, Route 1, Box 45, Kenai, Alaska 99611, Phone (907) 283-7872

Maple Leaf Millt, LTD., Seed Division, 9451-49 Street, Edmonton, Alberta T 6B 2L8, Phone 465-9984

Mulligan Farms, P.O. Box 2029, Palmer, Alaska 99645, Phone (907) 745-4728

Northern Lights Nursery, 1600 College Road, Fairbanks, Alaska 99701, Phone (907) 456-6336

Northrup King & Company, P.O. Box 1675, Billings, MT 59103, Phone (406) 252-0568

Northplan Seed Producers, N.A.P.G., Inc., P.O. Box 9107, Moscow, ID 83843 Phone (208) 882-8040

Palouse Seed Company, Inc., Box 291, Farifield, Washington 99012, Phone (509) 283-2213

Washburn Farm Nursery, P.O. Box 823, Palmer, Alaska 99645 Phone (907)745-3479

Source: Diamond Chuitna Mine Permit Application to Conduct Surface Coal Mining (1985), Diamond Alaska Coal Company

Table 4-4. Grass Seed Producers

Barney Hollembaek 895-4715 Mile 1403.5 Alaska Highway Delta Junction, AK 99737	Nugget Kentucky Bluegrass Tundra Glaucous Bluegrass Arctared Red Fescue
Bill Ward 262-5135 P.O. Box 356 Soldotna, Alaska 99669	Nugget Kentucky Bluegrass Arctared Red Fescue Norcoast Bering Hairgrass Sourdough ('86) Bluejoint
Dick Roberts 488-6525 Salcha, Alaska	Common Bluejoint Sourdough ('86) Bluejoint
Arctic Geo Resource Associates (Doug Witte, Mark Weaver, Ted Cox) 745-2436-day; 745-4308-night P.O. Box 1142 Palmer, Alaska 99645	Arctared Red Fescue Engmo Timothy
Bush Landscaping 344-2775 2848 Lore Road Anchorage, Alaska 99507	Arctared Red Fescue
Scott Miller 895-4073 2072 Tanana Loop Ext. Delta Junction, Alaska 99737	Norcoast ('86) Bering Hairgrass
Tom Williams 745-4000 SRB Box 7470 Palmer, Alaska 99645	Norcoast ('86) Bering Hairgrass
Alaska Mill & Feed 279-4519 Box 1246 Anchorage, Alaska 99510	Arctared Red Fescue
Pat Mulligan 745-4004 Box 2029 Palmer, Alaska 99645	Nugget Kentucky Bluegrass Norcoast Bering Hairgrass Engmo Timothy Arctared Red Fescue Alyeska Polargrass
Claud Oxford 741-4801-day; 376-5991-night P.O. Box 85 Wasilla, Alaska 99687	Engmo Timothy
Ted Pyrah 745-4551 LDS Welfare Farm Box 966 Palmer, Alaska 99645	Engmo Timothy

- Surface soil material should be segregated and stored for eventual use in reclamation. Stored topsoil should be temporarily revegetated to prevent erosion. Topsoil material should be replaced atop a scarified surface.
- Revegetation activities should become contemporaneous with mining activities as soon as possible. Such planning may allow one-time movement of topsoil and minimize recontouring costs.
- Seedbed preparation is the key to revegetation success. Seedbed should be loosened to a minimum depth of 6 to 8 in and left in a roughened condition. In areas of adequate precipitation and non-errosive slopes, good seedbed preparation by itself may be sufficient to encourage revegetation.
- Commercially available NPK fertilizer (e.g., 8-32-16) should be applied at 300 to 450 lb per acre during the first full growing season after site preparation is completed. Fertilization of disturbed areas should include adjacent undisturbed native vegetation to enhance seed production. Undisturbed areas will be a seed source for the disturbed areas.
- Vegetative material should be limited to native species unless steep slopes or erosive soils require stabilization by exotic species.
- Use of straw mulches should be avoided since it affects nutrient cycling and limits the availibility of nutrients to establishing vegetation. Straw mulch is appropriate for sand dune reclamation and in areas where additional reflectance is beneficial.
- Woody Species should be planted in disturbed riparian habitat. Cuttings have been shown to be more successful than direct seeding.
- In areas where woody species are to be planted or are desired, the seeding rate of grasses should be light so that grasses do not compete with establishing woody plants.
- Plant species requiring extended maintenance (e.g., watering, repeated fertilizing) should be avoided.

Detailed guidelines for reclamation planning for Placer Mines in Alaska is provided by the Alaska Department of Fish and Game (Entrix, 1986a and 1986b). Most of the recommendations are appropriate for mines on lands under the jurisdiction of the NPS. Reclamation structures should be limited to natural materials available from mine sites and plant materials used for revegetation should conform to NPS guidelines and requirements of individual national parks and preserves.

5.0 RECLAMATION COSTS FOR ALASKA ENVIRONMENTAL ZONES

Reclamation costs vary directly in relation to the extent of disturbance (e.g., recontouring necessary, etc.), the ease of revegetation, and site accessibility. Because of these variables, accurate cost estimates must be site specific.

5.1 GENERAL RECLAMATION COSTS

The following is a range of estimated reclamation costs for site enchancement (natural revegetation) and revegetation. These cost estimates will be the minimum costs to reclaim disturbed lands (per acre) since they do not include topsoiling or extensive recontouring or specialized techniques to address particular problems (e.g., mulches, seed collection and material production). Estimated costs assume large scale reclamation.

	$ Amount per acre
Site Enhancement	
Site Preparation (Grading)	$ 500 - 1,000
Fertilizer Application (Labor and Material)	250 - 350
Subtotal	$ 750 - 1,350
Site Enhancement and Revegetation	
Site Preparation, Fertilizer	750 - 1,350
Seeding (Labor and Material)	100 - 200
Planting (500 per acre @ $.50 per plant; 30 plants per hr; labor @ $10/hr)	450 - 500
Subtotal	$1,300 - 2,050

5.2 LOWER GLEN CREEK RECLAMATION COSTS

The ultimate cost of reclamation at the lower Glen Creek site will vary, depending on whether the work will be performed by the NPS or by a private contractor. Costs provided below assume a contract arrangement.

Movement of heavy equipment to the site may not be limited to winter in the Kantishna area, providing existing roads and crossings are possible. Costs for movement are expected to vary between \$3,000 and \$6,000, depending on conditions.

Although about fourteen acres have been disturbed by placer mining, much of the disturbance is in low piles or cleared areas which do not substantially differ from surrounding topography, do not present erosion/sedimentation problems, and which have started to revegetate naturally with willows, spruces, and forbs from nearby areas. The present plan assumes that these areas will be allowed to continue natural revegetation. Other assumptions for costs of reclamation are:

- Disturbed area - 10.0 acres
- Waste Rock Piles (37) - 5,500 yd^3
- Retention pond construction (4) - 5,400 yd^3
- Stream modification - 2,400 yd^3
- Stream material movement - \$1.50/yd^3
- Transportation, per diem, and report preparation are not included.

<u>General</u>:	
Mobilization/Demobilization - 40 hrs @ \$75/hr	\$ 3,000.00
Reclamation Supervisor - 420 hrs @ \$35/hr	14,700.00
Surveyor - 80 hrs @ \$35/hr	2,800.00
Rod and chain man - 80 hrs @ \$25/hr	2,000.00
Total vehicle costs (Supervisor, Suveyor, etc.) (\$75/day x 86 days)	6,450.00
<u>Salvage</u>:	4,500.00
<u>Recontouring and Construction</u>	
Tailings pile - 5,500 yd^3 @ \$1.15/yd^3	7,475.00
Stream Channel - 2,400 @ \$1.50/yd^3	3,600.00
Pond Construction - \$5,400 @ \$1.15/yd^3	6,210.00

Seedbed Preparation		
Ten acres @ $75/acre		750.00
Fertilizer		
Application @ $100/acre		1,000.00
Material @ 10 acre; 300 lb/acre		
3,000 lb x $.50/lb		1,500.00
Planting		
Cutting Collection-		
1,742 plantings per acre x 10 acres = 17,420 plants		
17,420 ÷ 100 plants/hr = 174 hr labor		
Labor $11.56/hr x 174 hr = $2,011		2,011.00
Cutting Planting-		
17,420 plants ÷ 30 plants/hr = 580 hr		
580 hr x $11.56/hr = $6,705		6,705.00
Transplanting-		
Assume 500 individual ÷ 5 plants/hr = 100 hr		
100 hr x $11.56/hr = $1,156		1,156.00
Fertilizer Trials-		
20 hr x $11.56/hr		232.00
Experimental Plot Implementation		
Topsoiling - 8 hr x $75/hr =	$1,200.00	
Plot Layout x 2 = 30 x $11.56	347.00	
Material =	$ 300.00	1,847.00
		$65,936.00

5.3 NELSON PROSPECT/RADOVAN GULCH RECLAMATION COSTS

Assumptions:

Radovan = 1 acre
Nelson = 4 acres
No reclamation on Nelson Prospect access road.
Transportation, per diem, and report preparation are not included.

Reclamation Supervisor[1]:		
214 x $35		$ 7,490.00
o Salvage =	50 hrs	
o Grading =	50 hrs	
o Seeding =	32 hrs	
o Fertilizer =	32 hrs	
o Plot layout =	40 hrs	
TOTAL	214 hrs	
Salvage and Close Adit:		
50 x $75		
Materials = $400		4,150.00
Mobilization (Helicopter rental)		
Helicopter costs include transportation of light duty equipment to the site for grading, tailing movement, and adit closure:		
3-3 hour round trips @ $1,000/hr		
10 hr x $1,000/hr		$10,000.00
4-3 hour plant trips @ $165/hr		1,980.00
Grading and Recontouring:		
25 hr/site x 2		
50 x $75		3,750.00
Seeding:		
Labor: 32 hr x % 75/hr = $1,600		
Seed: $200		2,600.00
Fertilizing		
Labor: 32 hr x $50/hr = $800		
Material: 1,000/lb x .50/lb = $500		2,100.00
Experimental Plot Layout:		
Material: $200		
Labor: 20/hr @ $35/hr = $320		700.00
Subtotal		$32,770.00

6.0 RESEARCH RECOMMENDATIONS

Placer mining, lode mining, mine access roads, and related disturbances have created demonstrable problems on lands now controlled by the NPS. While recent studies provide detailed guidance for reclamation at operating mines outside of national parks (Entrix, 1986a and 1986b), substantial modifications may be needed for reclamation and the preparation of mine plans for active mines within national parks and preserves. The development of suitable general methods for operation of mines within the parks, including the generation of mine plans and guidance on acceptable reclamation should be tested and developed as a guide to active mines for the benefit of the miners and the NPS.

Reclamation of abandoned mine sites within Alaskan national parks requires slightly different treatment. Sites which have been abandoned frequently have the following characteristics which make reclamation difficult:

- Placer mine waste rock piles have the original organic material on the bottom covered by the coarse alluvial substrate composed of gravel, cobbles, and boulders. The organic layer which may be stockpiled as mining progresses at active mine sites is thus unavailable on abandoned sites for use in reclamation, hence chemical fertilizers may be needed to augment revegetation.
- Waste rock piles on placer mine sites are often located in areas adjacent to the stream channel where they are subject to erosion, creating sedimentation and streambed compaction problems. Reclamation of these areas requires cleaning of the streambed to restore habitat, and removal of waste rock piles from the vicinity of the stream channel.
- Waste rock piles which have been abandoned for several years have begun revegetating naturally. Piles of unsorted waste rock between 10 and 20 years old on lower Glen Creek support willows several inches tall, small black spruce seedlings, and a variety of herbaceous species.
- Many methods for stabilization of the stream channel and enhancement of fish habitat proposed in current literature

employ artificial devices such as concrete deflectors, ceramic pipe, and wire baskets for creating rock barriers. The use of these unnatural materials is inconsistent with the reclamation aims of the NPS.

- Road and mine development in permafrost areas has created and may continue to create reclamation problems.

Additional research is needed to resolve these problems and to develop procedures to avoid these problems on active mine sites in the future. Specific studies might include monitoring of a variety of disturbed areas in addition to those described in the three experimental plans described herein (e.g., Friday Creek); studies of spontaneous revegetation on lode mine tailings in Wrangell-Saint Elias National Park; and the testing and development of procedures to prevent erosion, stabilize stream channels, and enhance habitat which use natural materials and require no post-installation maintenance.

Hazardous materials including solvents, petroleum products, and explosives are present on active and abandoned mine sites in Alaska National Parks. Reclamation at these sites can occur only after these materials have been disposed of by acceptable procedures. Additional problems may exist at larger mines (e.g., Kennicott near McCarthy in Wrangell-Saint Elias National Park and Preserve) where transformers containing PCBs may have been used and may have resulted in site contamination. An inventory of these sites, development of procedures (and priorities list) for site cleanup, and integration of hazardous waste concerns into mine site reclamation plans would be useful.

The previous studies indicate that additional research in reclamation techniques would greatly benefit future revegetation activities. Recommendations include the following:

- A literature review investigating the autecological characteristics (e.g., habitat, soil type, precipitation requirement, elevational range, metal tolerance, successional status) for native plant species (grasses, forbs, woody species) potentially valuable for revegetation. This

consolidated information would be useful as a planning guideline.

- Few native species have presently been tested for revegetation potential. Since re-establishment of native plant communities is an important reclamation goal, plant species testing needs to be supported or expanded. The Plant Materials Center in Palmer has been involved in these studies and coordination with the center would be valuable in developing species (e.g., metal tolerant species) that are valuable for disturbances which occur in the park system.
- Seed or stock of native plant species which have revegetation potential are usually not commercially available. Studies should be developed in cooperation with local farmers, greenhouses, or the Alaska State Forest Nursery, to improve seed production techniques so as to ensure a stable supply of seed.

Experimental reclamation on tundra areas should be attempted because of the fragile nature of these ecosystems and the severe climatic conditions which create special and difficult reclamation problems in these areas. Techniques could test methods for stabilization and/or restoration of the permafrost layer and resolution of problems created by its disturbance. Although a substantial body of literature exists on construction in permafrost areas, guidelines for mine reclamation which emphasize the use of natural materials in these areas have not been developed.

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APPENDIX A

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Potential Earth-Mining Contractors

Company	Individual	Address
Alaska Central Construction	Gene Criss	Wasilla, AK 99687
Alaskan Ventures Unlimited	Ed Martin, Jr.	P.O. Box 3166 Palmer, AK 99645
All-State Builders	Lonnie Ratcliff	SRD Box 9590-C Palmer, AK 99645
American Builders	Jim Janke	P.O. Box 772551 Eagle River, AK
Big Lake Enterprises	John David Clark	Walsilla, AK 99687
Big Lake Int.	Chester Godwin	P.O. Box 520930 ???, 99652
Cobb Enterprises	Les Cobb	P.O. Box 61340 Fairbanks, AK 99706
Dodds Construction	Keith Hooles	P.O. Box 20020 St. 117 Wasilla, AK 99687
Exploration Supply	Carl Ivey	6727 Old Seward Hwy. Anchorage, AK 99502
Great Northern Construction	Art Petersen	SRB 7445 Palmer, AK 99645
Kupperud Traus	Leif Kupperud	P.O. Box 805 Palmer, AK 99645
Lindco	Earl Lind	3119 Wiley Post Ave. AK 99507
Mat-Su, Inc.	Steven Geszy	P.O. Box 4-1911 Anchorage, AK 99509
Neura Reclamation	Greg Skoglund	411 E. 54th Anchorage, AK 99518
Pionier Drilling, Inc.	Albert Soterion	P.O. Box 871378 Wasilla, AK 99687
Psenak Construction	Jim Psenak	Box 1365 Palmer, AK 99645
Quadra Construction	Jim Ely	401 Fireweed Anchorage, AK
Strata Inc.	Harry David	P.O. Box 772946 Eagle River, AK
Woods Enterprises	Lynne Woods	Box 37 Sutton, AK 99674

APPENDIX B

APPENDIX B
Common and Scientific Names of Plant Species
(Page 1 of 3)

Common Name	Scientific Name
Grasses and Grasslike Species	
alpine bluegrass	Poa alpina
bluegrass	P. glacia
bluejoint reedgrass var. Aurora	Calamagrostris canadensis
cottongrass	Eriophorum sp.
polargrass	Arctagrostis latifolia
red fescue	Festuca rubra
rush	Juncus castaneous
sedge	Carex bonanzensis
Siberian wildrye	Elymus sibiricus
Forbs	
Alsike cliver var. Aurora	Trifolium hybridum
arctic sandwort	Minuartia arctica
black oxytrope	Oxytropis nigrescens
cinquefoil	Potentilla sp.
fireweed	Epilobium latifolium
moss campion	Silene ocaulis
mountain avens	Dryas drummondi
red clover	Trifolium protense
sagebrush	Artemisia tilesii
white dutch clover	Trifolium repens
white sweetclover	Melilotus alba
wild strawberry	Fragaria sp.
yellow sweetclover	Melilotus officinalis

APPENDIX B
Common and Scientific Names of Plant Species
(Continued, Page 2 of 3)

Common Name	Scientific Name
Shrubs	
Alaska bog willow	Salix fuscescens
Alaska cassiope	Cassiope stelleriana
Aleutian mountain-heath	Phyllodor aleutica
alpine azalea	Loiseleuria procumbens
alpine bearberry	Arctostaphylos alpina
American green alder	Alnus crispa
American red current	Ribes triste
American red raspberry	Rubus ideaus var. strigosus
arctic willow	Salix arctica
Barclay willow	S. barclayi
Barratt willow	S. barrattiana
barren-ground willow	S. frachcarpa sp. niphocloda
bearberry	Arctostaphylos uva-ursi
Beauverd spirea	Spira beauverdiana
Bebb willow	Salix bebbiana
blueberry willow	S. myrtillifolia
blue mountain-heath	Phyllodose coerulea
bog blueberry	Vaccinium ulignosum
buffaloberry	Shepherdia canadensis
bush cinquefoil	Potentilla fruticosa
Chamisso willow	Salix chamissonis
crowberry	Empetrum negrium
diamondleaf willow	Salix planifolia sp. pulchra
diapensia	Diapensia lapponica
dwarf arctic birch	Betula nana
dwarf blueberry	Vaccinium caespitosum
entire-leaf mountain avens	Dryas integrifolia
feltleaf willow	Salix alaxensis
four-angled cassiope	Cassiope tetragona
grayleaf willow	Salix glauca
halberd willow	S. hastata
high bush cranberry	Viburnum edule
Kamchatka rhododendron	Rhododendron camtochaticum
Labrador-tea	Ledum groenlandicum
Lapland rosebay	Rhododendron lapponicum
least willow	Salix rotundifolia

APPENDIX B
Common and Scientific Names of Plant Species
Continued, Page 3 of 3)

Common Name	Scientific Name
Shrubs (continued)	
littletree willow	S. arbusculordes
luetkea	Luetkea pectinata
Mertens cassiope	Cassiope mertensiana
mountain cranberry	Vaccinium vites-idoea
narrow-leaf Labrador-tea	Ledum decumbens
netleaf willow	Salix reticulata
ovaleaf willow	S. ovalifolia
Pacific willow	S. lasiandra
park willow	S. monticola
polar willow	S. polaris
prickly rose	Rosa acicularis
red-fruit bearberry	Arctostaphylos rubra
red mountain-heath	Phyllodoce empetriformis
red-osier dogwood	Cornus stolonifera
resin birch	Betula glandulosa
Richardson willow	Salix lanata sp. richardsoni
sandbar willow	S. interior
Scoufer willow	S. scouleriana
silverberry	Eleagnus commutata
Sitchell willow	Salix setchelliana
Sitka alder	Alnus sinuata
Sitka willow	Salix sitchensis
skeletonleaf willow	S. phlebophylla
starry cassiope	Cassiope stelleriana
sweetgale	Myrica gale
tall blueberry willow	Salix novae-angliae
thinleaf alder	Alnus tenuifolia
undergreen willow	Salix commutata
white mountain-avens	Dryas octopetala
Trees	
Alaska paper birch	Betula papyrifica sp. humilis
balsam poplar	Populus balsamifera
black cottonwood	Populus trichocarpa
black spruce	Picea mariana
quaking aspen	Populus tremuloides
tomarack	Larix laricina
white spruce	Picea glauca